THE ENGINEER

JANUARY 20, 1961 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS

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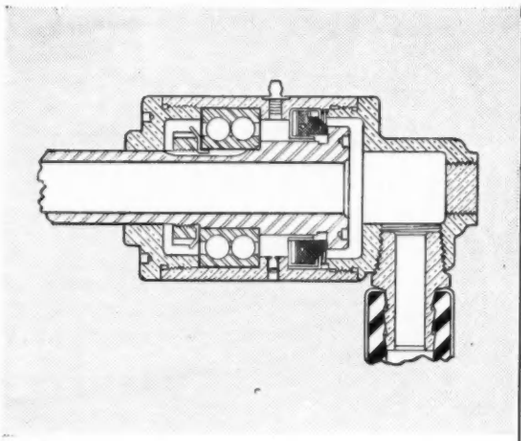
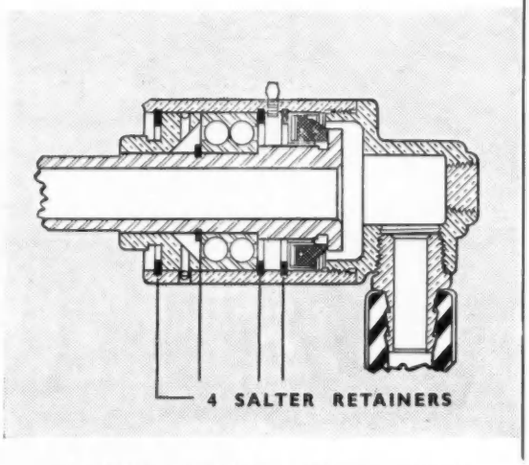


THE OLD WAY Air, water, steam union involved drilling, threading and milling operations. Maintenance was difficult.



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THE ENGINEER

Established 1856

No. 5478 **JANUARY 20, 1961** VOL. 211

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SUBSCRIPTIONS U.K. and ABROAD £5 10. 0. p.a., including postage (CANADA £5 5. 0.). Single copies 2s. each, plus 9d. postage. Also on sale at newsagents.

'THE ENGINEER' BUYERS GUIDE Published annually. One FREE copy is sent to all direct postal subscribers on publication and delivered by newsagents to all regular readers. Additional copies are obtainable at 7s. 6d. each. Postage 1s. 9d. extra.

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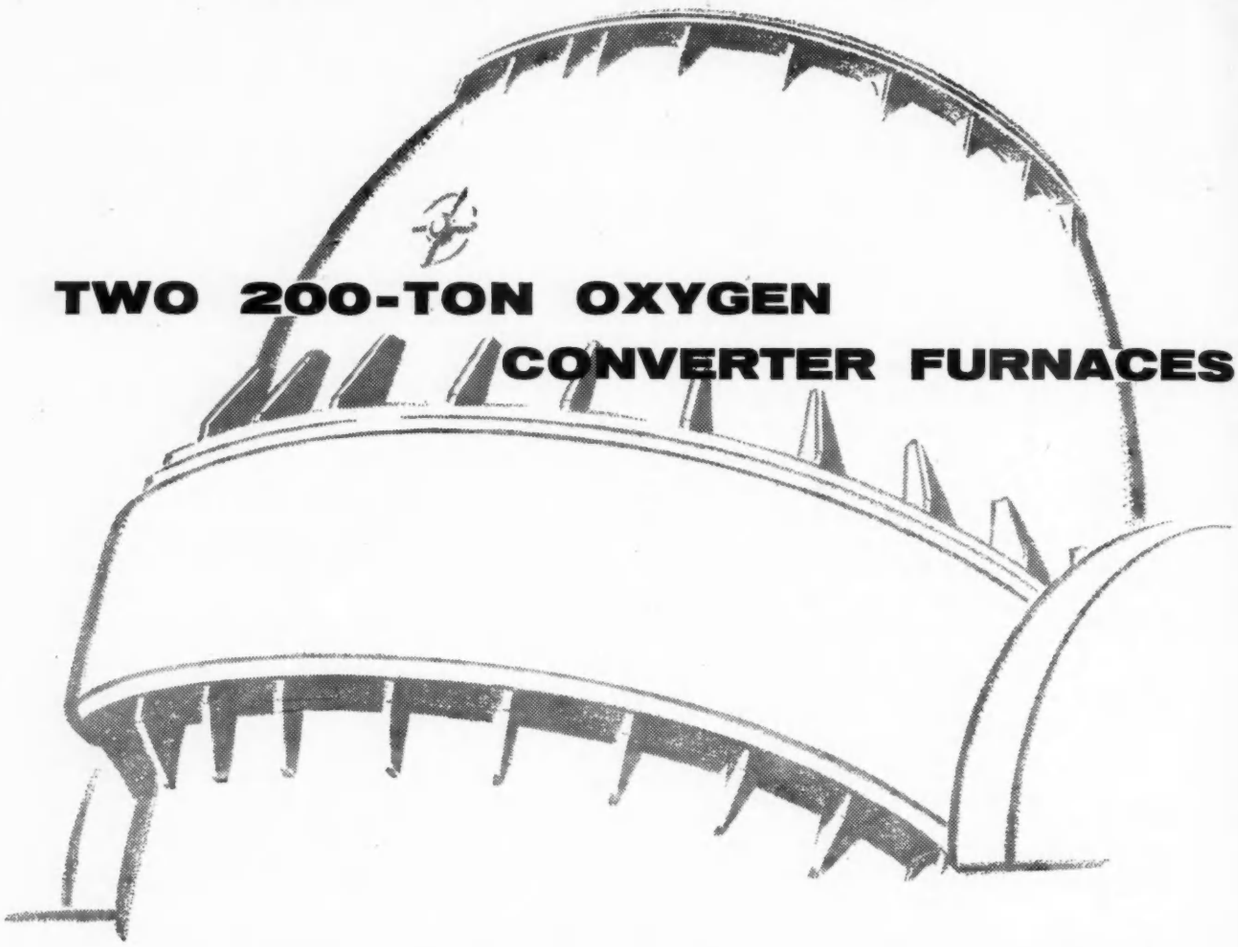
DAVY-ASHMORE to build



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Davy and United Engineering Company Limited, a member of the Davy-Ashmore Group, has secured the order to build two surface blown oxygen converter furnaces for the Newcastle Works, New South Wales, of The Broken Hill Proprietary Co. Ltd. Each of these furnaces will have a capacity at each charge of 200 tons of liquid steel.

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THE ENGINEER

No. 5478 JANUARY 20, 1961 Vol. 211

REMUNERATION OF ENGINEERS

In this month's issue of *The Professional Engineer*, the journal of the Engineers' Guild, there are published, as promised in December when an outline was made available, fuller details of a survey of engineers' remuneration conducted by the Guild during the past year. It will be recalled that in March last year there was published by the Royal Commission on Doctors' and Dentists' Salaries a survey of the remuneration of people in a number of professions including that of engineering and that it showed engineers to be the least well paid apart from architects. Those figures related to 1955-56. The new figures relate to 1959-60. As was to be expected they show a substantial rise in the interim, amounting to something like 30 per cent for those aged thirty-five to thirty-nine and 20 per cent for those aged forty-five to fifty-four. But even upon the unlikely supposition that those in other professions have experienced no similar increase in salaries, the increase still does not alter the lowly place of engineers in the comparative table at the higher ages, though it does suggest that there may have come about some improvement for younger engineers. But the "mean" figures covering engineers in all kinds of employment and at all ages conceal the fact that there are substantial variations. Breaking the figures down yields interesting results. The relevant tables are reprinted from *The Professional Engineer* on page 93 of this issue. It turns out that salaries paid by Local Authorities and Public Utilities are some hundreds of pounds per year less than those paid in industry, nationalised industry and the Civil Service; and that engineers "not in engineering occupations" are far better off than the rest! In addition, it is revealed that university graduates now attract substantially larger salaries than engineers who have not graduated, to the tune of £300 or so at the median level for younger men and of £1300 or so at the upper quartile level for the age group fifty-five to sixty-four. Even so — and still on the supposition that members of other professions are earning no more than in 1955-56—graduates in engineering only move a place or two up the comparative table. If remuneration in other professions has in fact risen at about the same rate as that in engineering even the engineering graduates, not to mention non-graduate engineers, remain last but one from the bottom. An exception must be noticed, however. Perhaps because there is some scarcity value involved, much more satisfactory salaries are commanded by chemical engineers both graduate and non-graduate. Omitting the "Chemicals" from consideration it is interesting to notice that whatever the institution of which they are members those who are non-graduates earn very similar salaries. But "Mechanicals" graduates command higher salaries than those of the other two. Possibly a scarcity factor rules here too; for of all four institutions the "Mechanicals" is shown to have the lowest proportion of graduates. It may be significant, however, that the Institution of Chemical Engineers, whose members are so well remunerated, has a far higher proportion of graduates than any of the other three.

A conclusion that must be regretfully reached is that the remuneration even of graduate engineers, except in chemical engineering, remains unsatisfactory. Another can be hesitantly suggested. It is that one of the reasons for the low salaries offered to engineers arises out of the fact that membership of the major engineering institutions has been open in the past to too wide a spectrum of engineers, from theoreticians and fundamental research workers at one end of the scale to men practical to their finger tips or particularly capable of management, but having very little competence in or even much interest in theory, at the other. Stricter limitation would make it possible for industry to assess more clearly what membership really means. There is undoubtedly a trend towards doing so. The major institutions are all tending to make it more difficult for those without a degree (or a Dip. Tech.) to gain admission to membership. Ever more sharply they are drawing a distinction between the technologist suitable for membership, and the technician, not suitable. Under the recent White Paper proposals the educational system of the country is to recognise the distinction too. The route to membership of an institution through national certificate courses has not been closed; but it is being made less and less attractive. Taking all four institutions into account some 46 per cent of their members under thirty-five years old are graduates, whereas in the age group forty-five to fifty-four less than 40 per cent are — the figures are drawn from the Guild's tables. Of course there is no need to draw invidious distinctions; should the institutions set still stricter limits upon membership technologists accepted for membership and technicians, excluded, may both benefit by higher salaries once the meaning of the distinction is well understood. Nor need it be necessarily supposed that those of technicians will be lower than those of technologists. The distinction may well become similar to that between architects and surveyors, the latter of whom command the higher remuneration.

GLOOM UNJUSTIFIED

In the course of a speech at the Fuel Luncheon Club recently Mr. H. E. Collins, National Coal Board Member for Production and Reconstruction, issued a warning that if, through a process of *laissez-faire*, the coal industry of this country was forced to contract and eventually there was a serious interruption of imported fuel supplies, it would be impossible in the short term to turn back to indigenous coal to supply the deficiency. He felt that estimates of this country's forward requirements of energy (300 million tons of coal equivalent in 1965) indicated that there would be scope for substantial increases in the use of oil without restricting coal usage to annual quantities insufficient to sustain an economic coal industry; and he suggested that the expansion in the use of imported oil should be so arranged as to represent an appropriate

share of the increase in the total inland consumption of primary energy. If a compact coal industry was to remain efficient there would need to be an annual output of about 200 million tons, equivalent in five or ten year's time to about two-thirds of the total inland primary energy requirements, leaving about 100 millions of coal equivalent to be supplied from other sources.

From the points made by Mr. Collins it is evident that he considers that coal should long continue to be of primary importance in planning the future energy requirements of this country. Few would disagree. But probably coal will never again be able to compete in price with oil for certain purposes and never be able to compete with it in convenience for certain other purposes. Yet if Mr. Collins had it in mind that regulation should be applied by the Government to ensure that the demand for coal is maintained into the future we do not think engineers are likely to approve. For the outlook for coal does not seem so very unfavourable. The closing down of older mines in favour of newer ones, more economic to work, combined with increasing mechanisation, should make it possible to hold the price of coal relatively stable. Recently the output per manshift has been rising fast. It should surely be possible to quote prices competitive for many purposes; even perhaps to revive the export trade. Furthermore the shrinkage in demand for large coal consequent upon reduced railway demand and the falling domestic demand must eventually favour the use in mines of the more highly productive coal cutting machines (which produce smalls not to mention dust!) and thus the raising of output per manshift still further and faster. It may very well be time that the industry should adopt a more aggressive sales policy than at present to ensure that prospective users know what varieties of coal and coal products are available and what economic appliances are being developed for burning them. But we see no reason why a policy of letting competition have free play should ruin the coal industry. Indeed, so fast is the demand for electric power rising, pulling with it demand for fuel, that it is certainly not beyond the bounds of the possible that within a few years the Coal Board may once more be under criticism for the low output of the mines and the inadequacy of stocks of coal suitable for power plants!

APPRENTICE TRAINING EQUIPMENT

During a recent works visit we were taken into a very well-equipped machine shop set aside for apprentice training and, recalling our own experiences of thirty or more years ago, looked with some envy on the fine modern machines the boys were using. Speaking of this later to one of the "old school" he commented that he thought that such good equipment might have been better used in the main production lines or tool room of the works and older machines should be used for training. With some degree of conscience, after fuller discussion we concluded that this was more an outcome of envy than practical thinking — for it was better to inculcate a full knowledge of the potential of modern plant than the difficulties and uneconomic ways such as had to be adopted to make components on machines not suited in size or capacity — as had frequently to be done in the past. To put it bluntly, it is not at all necessary for a driver of a Rolls-Royce to learn how to handle a vehicle or a farm tractor he will never be called upon to control.

It is all too easy for an engineer trained two or three decades ago to look at modern training methods with a jaundiced eye and say that if the new breed of craftsmen came against some of the problems of his day they would not be able to find a solution. But, in fact, a majority of lads now-a-days get a concentrated training in theory and practice which provides a far more comprehensive foundation for tackling problems in their future careers than an older generation ever experienced. What is probably as much to the point, they do not in the initial stages of their training, carried out under close supervision by experts, learn some of the less desirable short cuts in machine shop practice from operators who "get away with it" on the basis of long experience. Let apprentices have first-class machines from the outset to give them pride in craft and experience in using such tools. The experience will make them less tolerant in later life of ill-designed or worn out machines.

WORK AND LEISURE

There is an ever-increasing pressure for the reduction of working hours and while the fraction of the hours per week during which a man works at his particular employment has fallen substantially since the commencement of the present century, claims for still fewer working hours are constantly urged. Whatever may be the justification for (or the economic implications of) the shortening of working hours, insufficient attention is given to the question as to what use is likely to be made of the additional leisure. Those of us who, having served a trade apprenticeship, may be old enough to remember working for up to, say, sixty hours a week, will agree that in such conditions the desire for either physical or intellectual recreation was not likely to be overwhelming. To-day, every shortening of the working week suggests the importance of making good use of the free hours and we have all known those wise individuals who, appreciating the value of time, endeavour not to waste it. To such men leisure becomes a form of activity since — as was said by Pasteur — when one is accustomed to work one can no longer live without it. It should surely be deemed a matter of the highest national importance that provision be made for turning to the good of the individual (and of the nation) the vast amount of time represented by the greater leisure ensuing from the shortening of working hours. For a man who loves work, inaction can prove a sore affliction and a wise man of our time has affirmed that "what wears one out is not what one does but what one doesn't do."

It has been remarked that "sloth has ruined more nations than the sword" and there is a proverbial saying to the effect that the progress of an individual is represented by the work which he does minus the work which he *must* do. Thomas Jefferson has recorded how, while yet a student, he copied into his notebook the following lines from Young's *Night Thoughts*:

> "Youth is not rich in time; it may be poor;
> Part with it as with money, sparing; pay
> No moment but in purchase of its worth;
> And what it's worth, ask death-bells; they can tell.
> Part with it as with life, reluctant; big
> With holy hope of nobler time to come."

Time, the most valuable gift bestowed on us, is the one we are apt to squander recklessly, forgetting that the man who wastes his time can be a more lamentable spendthrift than he who throws away his money; the money may be recovered by industry, the time wasted is irretrievably lost. Only the true worker can comprehend the value of time. "Ask me," said Napoleon, "for anything but time." That the future of our country must be influenced by the use made of the constant increase in the leisure time of its citizens is a proposition not to be doubted. The extension of leisure brings its own prob-

lems and it was pointed out some time ago that in the United States as many as 3,500,000 workers held more than one job. A major function of leisure is, of course, physical and mental recuperation, but not all of the 126 non-working hours available in a forty-two-hour working week are needed for sleep and recreation. Those hours which are at a man's unfettered disposal constitute a truly valuable asset which, expendable as he himself decides, can be either used or wasted. Some years ago the Director of Education in a North of England town related the following story regarding the first class which he took in a Workers' Educational Association. There was present on this occasion a man who had been mentioned as both unsuitable for tuition and without interest in books. During the discussion on the first night this man kept silent. On the second night — the subject being the history of Byzantium — the man astonished everybody by joining in the discussion and not only criticising the lecture but showing quite conclusively that the lecturer was wrong. The Director of Education added that he took this class for three years, during which time the man in question "never missed a single class night, and on most nights contributed something valuable to the discussion." It transpired that he knew Gibbon's *Decline and Fall of the Roman Empire* from the first page to the last.

Education being the greatest leveller in society, nothing is more to be desired than that the raising of the standard of living should be accompanied by a raising of the standard of education, and this is surely an avenue opened up by increase of leisure. One of our prime ministers — Lord Baldwin — has expressed the opinion that "There is no real Republicanism except that of literature. If I find a human face light up at some quotation which everyone ought to know; that man, be he duke or dustman, is my brother. That is the bond of literature." Perhaps Lord Baldwin had in his mind some words uttered about twenty-five centuries earlier by Confucius, who is reported as having remarked that "Where there is education, there in no distinction of class."

BRITISH EXPERIMENTS IN SPACE

Progress since January of last year in working out details for the first British/American satellite has resulted in completion of the vehicle's preliminary design and general layout. It will be known as International Ionosphere Satellite S-51 (or, more shortly, U.K. No. 1) and should be launched in about a year's time. A joint statement by the Office of the Minister for Science and the Royal Society has recalled that the project stems from an offer made in 1959 by the U.S. National Aeronautics and Space Administration to provide launching facilities for experiments of mutual interest prepared by scientists of other countries. In this case the launching system will be a Scout four-stage solid-propellant rocket, and the launch will take place from Wallops Island, on the East Coast of the U.S.A., into an orbit which will carry the satellite over the United Kingdom.

While the final choice of experiments has yet to be decided, some details of the instrumentation have been made known already. The scientific instruments are being made in Britain, and in our November 18 issue we illustrated a transistorised X-ray spectrometer built up on 5½in. diameter cards which will be used in one of the experiments of the Space Research Group of University College, London, and the Physics Department of the University of Leicester. Probes and sensor electrodes for this and other experiments will be carried on booms which will swing out radially from the satellite after launch. The satellite itself is to be roughly spherical in shape and nearly 2ft. in diameter. Four telemetry antennæ will transmit in the 136-137 Mc/s band to ground stations, either directly from the instruments or from a tape recorder which will store data gathered during orbit. This recorder will play back when commanded by certain ground stations, one of which will be the United Kingdom Radio Research Station at Slough. The experimental data will be available first to the United Kingdom scientists responsible for the instruments in the satellite. Several watts of electrical power will be generated by solar cells carried in four paddles and will be used to charge batteries in the satellite. This power supply will be designed to operate for a year, after which the radio transmitters will be switched off. The structure, telemetry system, tape recorder and power supplies are the responsibilities of the U.S. National Aeronautics and Space Administration.

The recently published report of the Radio Research Board in this country expressed keen interest in proposals for sounding the ionosphere by means of satellites, and recommended that experiments of this nature should be designed by the Radio Research Station for flying in satellites such as U.K. No. 1. It also recommended the participation of Slough in the reception and analysis of data. The Radio Research Station has practical experience in prediction of nearest approach and range of satellites based on measurement of the Doppler frequency shift in the received signals and is now operating a Minitrack station at Winkfield for tracking and telemetry. The reception of signals from satellites in itself, when studied in conjunction with positional information, provides evidence on modes of radio wave propagation previously unobtainable. When this is combined with the telemetered results of direct observations of the ionosphere, radio stands to benefit by knowledge which was not only unobtainable earlier in its history, but undreamed of.

The Engineer—100 Years Ago (JANUARY 18, 1861)

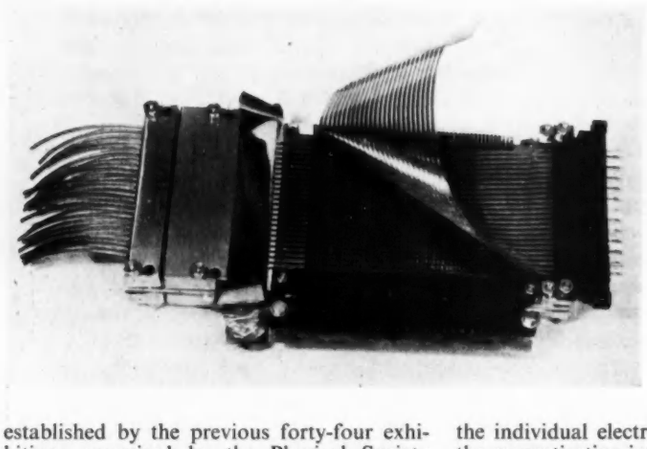
"M. LOVE'S PAPER ON ELECTRICITY"

"Years ago it was suggested that electricity, not perhaps the intense fluid which disintegrated every physical obstruction to its course, but some more refined modification of the same fluid elaborated in the organism itself (for which purpose anatomy may yet tell us the brain is adapted), influenced and directed by the WILL, produced all the phenomena of life. Slowly one by one scientific men have been forced into a state bordering on conviction of the truth of this suggestion, till, finally, M. Love steps forward and almost declares it to be true. "'It has been proved,' he says, 'that free electricity will not only contract the muscles, but will continue the delicate functions of the organs of digestion after animal life is extinct.' If, then, this fluid in a crude state, directed in a rude manner, has operated in producing both the voluntary and involuntary action necessary to the production and perpetuation of organic existence, what doubt can remain but that the same fluid suitably modified and directed by the will in due proportion gives motion, energy, life, to all classes and forms of sentient being?"

Physics Exhibition

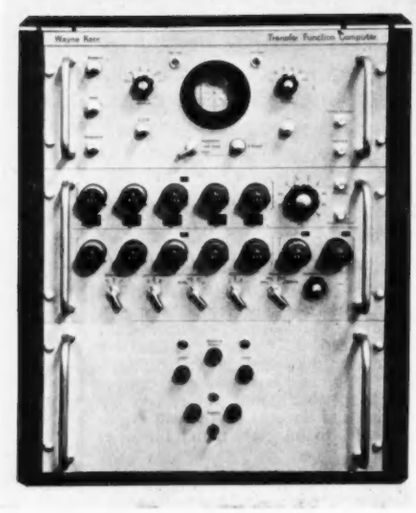
The Physical Society's annual exhibition of scientific instruments and apparatus is one of the activities which has been taken over by the amalgamated Institute of Physics and Physical Society. This year the exhibition is again being held in the Royal Horticultural Society's Halls, Westminster, London, S.W.1. It closes to-day (Friday) at 1 p.m.

THE 1961 annual exhibition of the Institute of Physics and The Physical Society is able to show practical results of numerous ideas mooted some time ago, such as applications of tunnel diodes, further development of magnetic storage media, and the thermoelectric cooling effect. The Institute and Society's own stand displays information relating to education in physics at all levels, which is one of the amalgamated body's major activities. The high proportion of equipment displayed which is still in the development stage maintains the tradition established by the previous forty-four exhibitions organised by the Physical Society alone.



Magnetic film digital store

Thin magnetic films for computer storage purposes are shown by four exhibitors. The magnetic thin film memory of International Computers and Tabulators, Ltd., makes use of a new alloy called " Gyralloy " which can be deposited by vacuum evaporation on to plates 4in by 3in. Each plate is arranged to store 1250 bits. We illustrate above a two-plate memory of this kind. With such devices the cycle time is limited by the driving circuitry at present available and not by the physical switching process in the storage medium, which is probably about one nanosecond. This rapid changeover from state to state is a characteristic of the magnetic film. In computer stores information is represented by remanent magnetism in a storage element. The element may be set north-south to represent a 1, say, or south-north to represent a 0. The problem in the design of very fast storage devices is to achieve the rapid change from one state to the other, which involves reorientating all the individual electron spins contributing to the magnetisation into the opposite direction. There is a time limit to the reorientation of an individual electron spin of about 10^{-9} seconds. In most magnetic materials, including computer store ferrite cores, all the electron spins reorientate sequentially, leading to a long total time. For ferrite cores this is 10^{-6} seconds. However in magnetic films all the electron spins can reorientate together thus leading to a switching time as small as 10^{-9} seconds. This is known as the " coherent rotational mode " of switching.



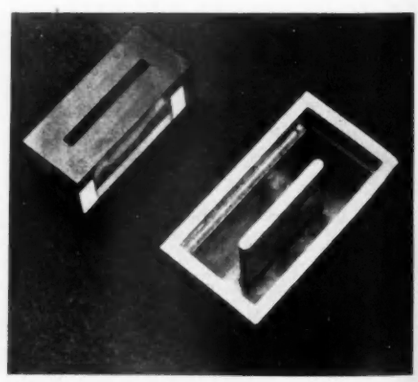
Transfer function computer

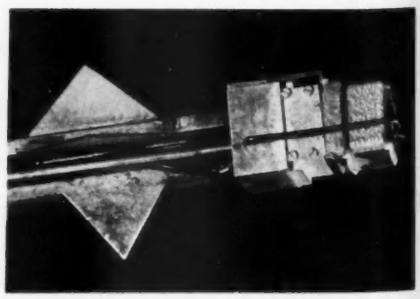
A further characteristic of the device illustrated arises from the deposition of the film on to an aluminium substrate. The presence of a conductor so near to the film enables a good signal-to-noise ratio to be obtained and reduces the drive impedance, because magnetic flux cannot penetrate into the conductor in the duration of the selection pulses. It is stated that no damping effect on the magnetic reversal has been found with this arrangement.

Another storage technique is shown on the stand of Ferranti, Ltd., in a section of the fixed store of the " Atlas " computer. This is constructed from removable ferrite rods in a mesh of conductors. The store, which contains 8000 words and has a short access time of only 0·2 microseconds, was developed at Manchester University. Each storage element is in effect a small transformer with primary and secondary windings magnetically linked by a ferrite rod. The two binary states 1 and 0 are determined by the presence or absence of a ferrite rod, e.g. when current is passed through the primary, a 1 signal is produced in the secondary if a rod has been inserted. The cost of this form of store for permanent information which may be pre-set is estimated to be about a tenth of the more conventional magnetic core store as the principle of construction is much simpler. Setting is effected by the insertion of pegs into socket boards.

A specialised computer shown by The Wayne Kerr Laboratories, Ltd., is designed for the rapid measurement of the transfer function of control systems of all kinds. It allows the engineer to see whether a feedback signal is conveying information to the system input which will produce a correct and immediate response. A signal provided by the computer is applied to a system under test, and the output of the system is fed back to the computer. Generally an ellipsoidal figure will be seen on the cathode-ray tube of the instrument, in which the input signal is applied to the X plate and the output signal to the Y plate. If the controls seen on the centre panel of the instrument illustrated are then adjusted to produce a straight line display, the numerical values of the unknown coefficients in the system equation may be read directly in the " windows " of each control knob. Solution of the equation enables an appropriate equalising network for the system to be designed, or the form of the feedback signal may be modified. The level of feedback needed for a given control purpose may also be minimised. Non-linearities in a system show up as a variation of the coefficients at different amplitudes.

Five stands show tunnel diodes this year and illustrate their application in logic and memory circuits. The use of a variable-capacitance diode in a new parametric amplifier technique, now under development, is illustrated in a demonstration on the stand of Marconi's Wireless Telegraph Company, Ltd. This u.h.f. amplifier is contained in a single length of X-band (3cm) waveguide, a method of construction applicable to any frequency in the u.h.f. range. The amplifier requires no u.h.f. isolator or recirculator. Conversion of the signal to the X-band and





(Above) Ruby block and resonant cavity of maser. (Below) Maser assembly, showing waveguide for pump frequency, coaxial connector and tuning probe

amplification occur by interaction in the diode, which is fed with a pump frequency of about 9000 Mc/s. The signal is then reconverted to its original frequency by a conventional crystal mixer. It is shown that the down-conversion loss is much less than the intial up-conversion gain.

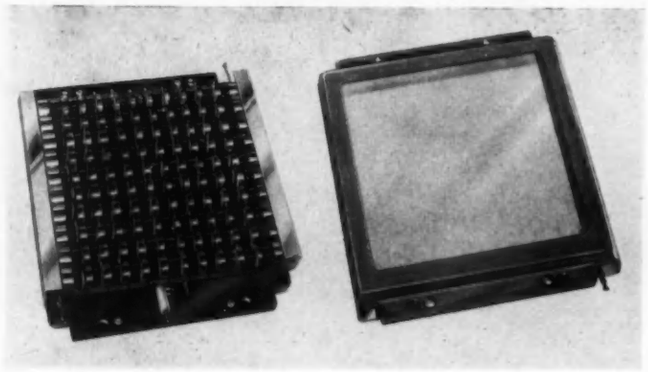
Another form of amplifier of which more has been heard during the past year is the maser, and an example of such a device developed from an earlier version which has been used in an *S*-band radar system at the Radar Research Establishment is shown by Mullard, Ltd. The maser on show (page 68) uses as its amplifying material ruby in a coaxial cavity. It has a gain-bandwidth factor of the order of tens of megacycles, at an operating temperature of 1·8 deg. K. The operating frequency is around 3·0 kMc/s.

The magnetic field required to produce the appropriate splitting of the magnetic energy levels for this frequency of operation is provided by a solenoid wound with niobium wire which becomes superconducting at the temperature of operation. This allows a persistent current to be set up in a superconducting circuit including the solenoid. By this arrangement a very steady magnetic field is obtained without elaborate electronic stabilisation. The maser amplifier in this practical form is suitable for outside site operation such as with a radio telescope or radar. Total weight of the maser, including the refrigerant, is approximately 80 lb, and it will operate for six hours to eight hours on one filling of refrigerant (liquid helium and liquid nitrogen).

Among electrical measuring instruments, digital presentation increases and is finding its place in less expensive devices than heretofore. One of these is a digital read-out meter by Nash and Thompson, Ltd., in which a press-to-read switch on the front panel operates a self-balancing bridge electromechanically linked to the indicator unit. Changes of digital readings take a second or two. Readout is by a mechanical counter.

A digital presentation of absolute voltage is combined with a meter display of variations as low as 1mV in the source under test in the TF1377 suppressed-zero voltmeter of Marconi Instruments, Ltd. (below). This is a potentiometric slideback instrument for measuring absolute voltages up to 500V d.c. It can also be used as a conventional differential voltmeter with a range of ±1mV to ±50V. In the slideback, or suppressed-zero, mode of operation, the source voltage is backed off against a potentiometer-controlled internal d.c. supply, using the centre-zero meter as null indicator. The absolute voltage of the source is indicated by the digital readout of the potentiometer, and subsequent variations in voltage are shown on the meter. In the differential mode the potentiometer is switched out of circuit, and small unknown voltages are indicated directly on the meter. Rectifier probes are available for extending the use of the meter to radio and a.f. measurements.

Suppressed zero voltmeter



Electroluminescent panel and delay lines for pulse display

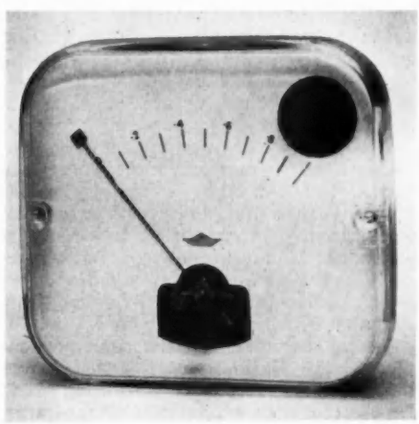
One of the demonstrations by G. V. Planer, Ltd., includes a new method of displaying the timing, time duration and amplitude of electric pulses by the use of a delay line associated with a multi-element electroluminescent panel (above). Pulses, which may be as short as five millimicroseconds, are directed towards each other from opposing ends of the delay line ; the increased voltage arising at the points of coincidence of the oppositely travelling waves causes excitation of the associated discrete zones of the phosphor panel, the example illustrated having 100 such zones. The system has interesting potential uses in pulse work, &c., in replacing oscilloscope displays for certain applications.

A demonstration is given of one of the display panels, showing the movement of the excitation zone as a result of varying time delays between the two oppositely applied pulses.

The same exhibitor shows a continuous response mercury levelling switch developed in conjunction with the Royal Aircraft Establishment, Farnborough. The device comprises two integral oxide film tracks adherently deposited in the interior of a gas-filled glass envelope. The tracks are bridged by a drop of mercury which is free to move longitudinally. An output varying with the angle of tilt in accordance with any desired law is provided, the output being normally in the form of a current difference in a pair of identical load coils. The switch is made in two forms, the law being determined by (*a*) the envelope shape or (*b*) the track configuration. The degree of damping can be adjusted to requirement. Resistance is of the order of 1500 ohms for each of the two tracks ; the maximum current rating is 50mA. Output conforms to the prescribed law to within about ±1 per cent.

For on/off control in accordance with detection of a predetermined current or voltage measurement, R. B. Pullin and Co., Ltd., shows a high-sensitivity controller (right) which imposes no extra load on the meter movement. This is achieved by using a flag at the pointer tip to interrupt light reaching a small photo-transistor from an internal source, and reflected on to the cell. This photo-transistor normally maintains the energisation of a relay having heavy-duty contacts rated at 3A, 200V to 250V a.c., but the relay is released when light reaching the cell is interrupted. Accordingly the equipment fails safe, since release also takes place on failure of the internal illumination source or of the mains. One or two control points for up-sensing or down-sensing may be provided. When only one setting is required, this may be adjusted by external shunts or multipliers to any electrical sensitivity.

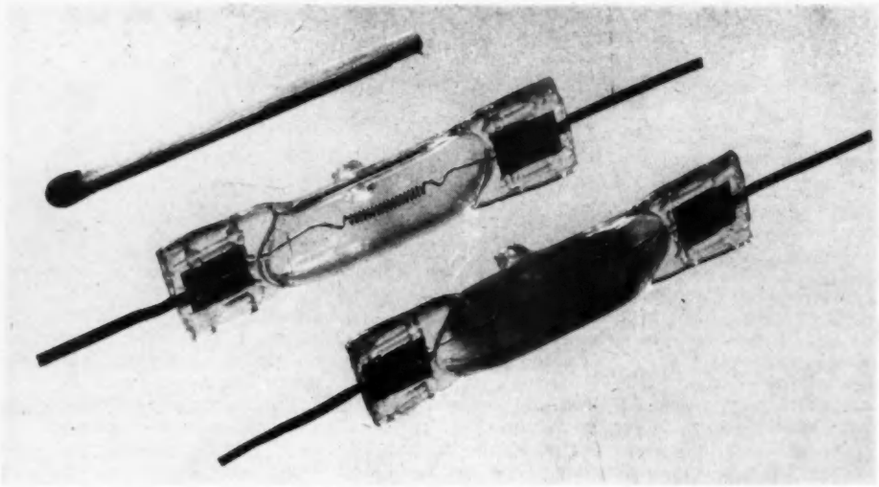
A detection and control system using a principle with wide applications in process control for the petrol and petrochemical industries, ventilation and combustion studies is demonstrated by Standard Telephones and Cables, Ltd. In the form exhibited, it uses optical infra-red filters to detect the presence of carbon-dioxide in the human breath. Infra-red radiation emitted by a hot filament is mechanically chopped and then passes through two parallel optical systems which are identical except in one respect : in the test cell the light passes through a sample of the human breath, whereas in the parallel standard cell the sample is drawn from a normal ambient atmosphere which has a relatively very low carbon content.



On/off controller with photo-transistor relay control

In both cells a combination of infra-red filters selects a particular narrow band of wavelength in which carbon dioxide is strongly absorbent. Finally, the transmitted radiation in each cell falls on a photo-conductive detector. The electrical signals from the two photo-conductive detectors are balanced and then the carbon dioxide is introduced into one of the cells ; an unbalanced signal results which is amplified and displayed. Carbon dioxide has been chosen in this instance for safety and convenience of demonstration. The basic method would enable any gas, liquid or solid to be detected which is known for some characteristic absorption or emission at a specified wavelength.

Among exhibits relating to illumination, The General Electric Company, Ltd., demonstrates how the addition of a small quantity



Iodine-treated lamp (above) compared after thirty-six hours' running with a normal gasfilled lamp which has darkened after some three minutes' running. These lamps are experimental

of iodine vapour to the gas filling in a tungsten filament lamp can markedly reduce the evaporation rate of tungsten from the filament and improve the performance. Certain other design requirements must be met, the most important being that the lamp must be small in relation to its wattage dissipation in order to hold the envelope at an adequately high temperature for maintaining the regenerative cycle. The small size and performance of lamps treated in this way make them suitable for applications where an approach to a point source is required for optical control of the light, but with a normal tungsten lamp rapid blackening of the envelope would be a problem (above). Examples are cinema projection and lighthouse lamps. A further experimental application made possible by their small size is the incorporation of such lamps within the bulbs of h.p.m.v. fluorescent lamps such as for streetlighting, to act as ballasts in place of the usual external choke. At the same time advantage is taken of improved colour rendering from the tungsten filament. In addition to new semiconductor devices, valves and magnetic films for information storage, the G.E.C. displays a range of thermoelectric cooling assemblies with powers from a fraction of a watt up to about 10W.

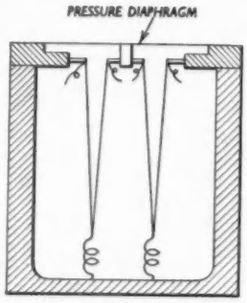
Among exhibits of telecommunications interest, the Harlow Research Laboratory of Associated Electrical Industries, Ltd., demonstrate a new principle in quadrature modulation for single sideband generation. Present methods are usually based on filtering to suppress the unwanted sideband, or on a quadrature system in which two outputs contain both sidebands, but the unwanted one is in antiphase so as to be self-cancelling. A multiplier stage is required in each channel, and the control of phase and amplitude stability in these stages is critical. The method being developed by A.E.I. uses an adder in each channel, these circuits having linear characteristics and being easier to control. Only one multiplier is required, and the components of the signal are such that only a simple form of filter is required. The circuit is applicable to independent sideband modulation by appropriate phasing of the inputs.

This company is among the many showing new semiconductor devices; exhibits by its Valve and Semiconductor Division include silicon microwave diodes and miniature all-glass-encapsulated fast-recovery diodes, zener diodes and silicon junction diodes. In a new form of diffused transistor shown by Standard Telephones and Cables, Ltd., a very thin layer of high-resistivity material to form the collector region is deposited on a slice of low-resistivity material. The transistor is then made by solid-state diffusion into the high-resistivity layer, using standard techniques. A very thin collector region is obtained on a low-resistivity backing which gives mechanical strength and simplifies handling. Transistors made by this process, known as "epitaxy," are stated to combine the two hitherto incompatible qualities of high breakdown voltage and low collector series resistance.

An unconventional application of the resistance strain gauge, a "Zero-Length" gauge evolved by Statham Instruments Inc., U.S.A., is displayed by J. Langham Thompson, Ltd. In this instrument an unbonded wire is folded in two so that the ends of the active length are superimposed; hence temperature corrections for dimensional changes are eliminated. The mid-point of the wire is constrained by a spring which is of low rate compared to the gauge wire; the result is that differential movement of the two ends does not change the total tension in the two wires but does alter the distribution between the two. A secondary advantage of the use of a spring anchorage is that there is no need for a positive stop to protect the gauge from overstrain, and further it is possible to use much higher gauge currents because expansion and contraction of the wire are absorbed by the spring; in practice, outputs of 25mV per volt are, we are advised, easily achieved.

J. Langham Thompson, Ltd., it may be recalled, also market oscilloscope cameras based upon Polaroid-Land camera units. A significant development with respect to the rapid process Polaroid camera is that there are now available films which give, instead of a positive on paper, a transparency; this means that the oscillograph trace can easily be magnified by the use of a projector, facilitating measurements of ordinates and slopes. The processing of a transparency needs two minutes instead of the one for a print; it is then removed from the camera, hardened by immersion in a "Dippit," and then inserted in a cardboard mounting. The transparencies lend themselves not only to projection but also to tone diazo and lithographic copying techniques. If required, negatives, duplicate transparencies, or paper prints can be prepared. Slides presenting charts or titles are readily made by the use of an ordinary Polaroid camera. The sizes available are 2¼in square, for use with a Polaroid projector—the mounting is in this case noteworthy, as it is devoid of symmetry to prevent pictures being inverted—or 4in by 3¼in, the conventional lantern slide.

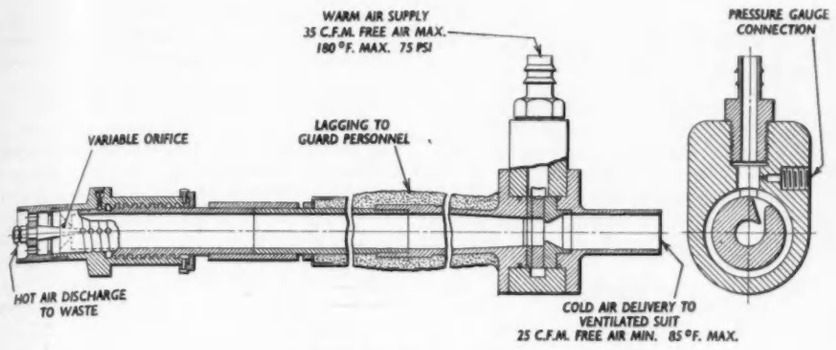
The accompanying photograph shows a model of a man wearing a ventilated suit for which cooled air is provided by a vortex tube. The problem of delivering cooled air to the suit in an ambient temperature of up to 180 deg. Fah. (ship's engine-room) was the responsibility of the Admiralty Engineering Laboratory, which concluded that systems in which the whole of the air consumed was cooled—for instance, by Joule-Thomson effect over the very large pressure differential available from the ship's 4000 lb per square inch main—were impractical because the hoses leading to the suit would have to support large gradients of either



Zero length strain gauges in pressure transducer

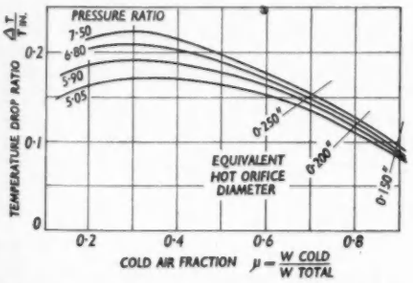
pressure or temperature. The effect first observed by Ranque, that a radial temperature gradient is stable in a vortex, was therefore exploited, air being supplied at ambient temperature and a pressure of the order of 70 lb per square inch and separated into two

Model showing vortex tube attached to ventilated suit; the wandering lead in the left hand is connected to a compressed air main


WARM AIR SUPPLY
35 C.F.M. FREE AIR MAX.
180 °F. MAX. 75 PSI
PRESSURE GAUGE CONNECTION
VARIABLE ORIFICE
LAGGING TO GUARD PERSONNEL
HOT AIR DISCHARGE TO WASTE
COLD AIR DELIVERY TO VENTILATED SUIT
25 C.F.M. FREE AIR MIN. 85 °F. MAX.

Section through vortex tube

streams, a hot exhaust and a cool input to the suit. An explanation of the functioning of the vortex tube was not forthcoming until fairly recently, although the effect was observed in cyclone furnaces in 1933 ; a theory can be derived from the assumption that the effect of viscosity will be to impose the velocity distribution of a forced vortex, $u/r=\omega$, upon at least the core of the vortex, in which case equilibrium between pressure and density, $dp=\omega^2 . \rho r\, dr$, demands that the air at the larger radii be compressed and therefore heated. The core of the vortex will be at relatively low temperature and pressure, but if the escape of hot air is suitably throttled cooled air will be delivered at the pressures of a few inches water gauge which are required. Our drawing shows that the hot exhaust is located at a large radius, but in fact this is merely for convenience of adjustment and the tube will function with both hot and cold orifices centred on the axis, the results from such a configuration being plotted in the chart ; this departure from the theoretical configuration is acceptable for rather long tubes only, as the dotted lines on the chart show. The tube is lagged to prevent the wearer from burning himself, and the exhaust is silenced to allow the wearer to hear messages.



Performance of vortex tube ; operating lines refer to an experimental tube of reduced length

Cawkell Research and Electronics, Ltd., displayed the Horstman bolt dynamometer, a simply constructed device to indicate the load in a bolt with moderate accuracy and fair long-term stability. It uses photo-elastic techniques, so that a reading is obtained simply by counting fixings ; no complicated or delicate apparatus is required. The device, devoid of its plastic case, is seen in our illustration ; a relationship between load and displacement is generated in a collar, stressed in compression, of Polypenco "Nylatron," which consists of "Nylon" 66 filled with molybdenum disulphide, and we are advised that over periods of months dimensional stability has been maintained under load. Onto a flat face on the perimeter of this collar is attached a reflecting layer and a lamination of bi-refringent "Stress-X" ; polarised light is applied simply by laying a filter of Polaroid material upon the photo-elastic layer and, as our photograph shows, fringes become plainly visible. In use, all but one segment of the cell is obscured, so that there is no risk of an unskilled observer counting a fringe on each side of the centre as two. The key seen projecting from the device is used to load the bi-refringent disc so that a suitable

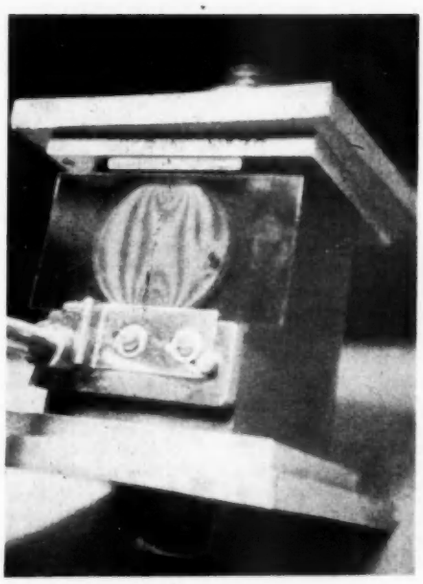


Photo-elastic bolt dynamometer, showing fringes

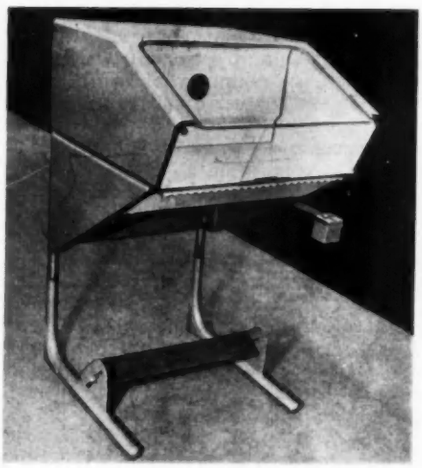
number of fringes are visible at the beginning of the working range. It can be seen that this device promises to be a simple and practical tool for such purposes as adjusting torque-limiting wrenches.

Existing electrical tachometers, other than those for spark-ignition engines, use the electrical circuit merely as an extremely flexible transmission serving to reproduce the subject speed at a point where it is convenient to measure it. A more sophisticated tachometer which dispenses with the need for a generator and drive was displayed by Kelvin and Hughes, Ltd., and is claimed to afford an accuracy of 0·1 per cent. The senser is a two-pointed magnetic probe which is mounted opposite a gear wheel or ring, so that the reluctance of the magnetic circuit formed by the probe and the gear varies cyclically once every tooth pitch. A coil in the probe thus receives an alternating excitation and the frequency of the induced voltage is derived by an instrument located remotely. If a "per cent full speed" presentation is chosen, the frequency corresponding to 100 per cent can be altered at the instrument, and so no modification of the engine can be called for. The instrument displayed was designed to run off a 400c/s

Pick-off for electronic precision tachometer

supply, but d.c. instruments are in the design stages. The pick-off needs no maintenance, is unaffected by lubricants and is more resistant to high temperatures than existing tachometer generators ; it is hoped to secure approval for its use in aircraft.

Assembly Cabinets



Component assembly cabinet with filtered air supply

CABINETS for the assembly of miniature servo-motor components in dust-free conditions before inspection and testing have been designed and manufactured by Plannair, Ltd., Windfield House, Leatherhead, Surrey, for use in the new Vactric (Control Equipment), Ltd., factory at Acton. Air is drawn through two filters at the back of each cabinet, where it is heated and then delivered into the assembly area by a Plannair 5in axial flow blower providing a filtration of five microns. The assembly area of the cabinet consists of a transparent roof and a transparent door which, when opened, automatically switches on a light. The operator inserts his hands one on each side of a narrow "Perspex" flap. This prevents him from inadvertently drawing a component forward into unfiltered air during assembly, since in order to do so he would have to leave go with one hand. As seen in the illustration, the roof has no horizontal crosspiece to restrict the operator's vision. The height of the assembly area is adjustable and the cabinet stand is supplied with an adjustable foot-rest. There are no restrictions on smoking during assembly, an ashtray being fitted within easy reach on the right of the cabinet.

[Reply Card No. E711]

Trans-European Road Haulage

This week there was delivered to the Institute of Road Transport Engineers a lecture entitled "The Design of Commercial Vehicles for Transcontinental Haulage" by Mario Persia, chief engineer and director, Technical Department (Commercial Vehicles), Fiat S.p.A.; it was read on Monday in Glasgow, on Tuesday in Colchester, on Wednesday in Nottingham, on Thursday in London, and is today to be given in Cardiff. We reproduce below the essence of this address.

THE transportation of goods on an international basis by motor transport, which has been developing steadily since the end of the second world war, could be further extended to more distant countries, provided the authorities would conform to the principles established by the International Road Transport Conference of Geneva, 1949, principles which appear nowadays to be forgotten.

How can the feeling of intentions being too partially directed be avoided when the European transport ministers are suggesting for international road transportation the regulation lately enforced by the German Republic (July, 1960) which appears convenient for short distance operation, as combinations reduced in length and weight seem to be out of competition ? If such rules are being considered from the standpoint of safety, it must be concluded that this particular aspect of the question (which appears to concern the authorities so deeply) has been completely neglected, as the Rules envisage increasing articulated vehicle length to the dangerous limit of 50ft. Moreover, how can the existence of motorways be ignored by the authorities, when such modern transportation systems are increasingly developing, year by year?

Therefore, in speaking of intercontinental transportation, one must first deal with appropriate regulations ; appropriate, that is, to the road system to be used and to progress in automotive techniques. The particular theme of this paper cannot be approached until we have defined, first, the road system through which vehicles must operate ; secondly, which vehicle is most suited to intercontinental transport ; thirdly, weight and dimension regulations to which it must adhere.

The writer has his opinion about these arguments, with the suggestion to manufacturers that their standardisation work concerning the various unions for attaching combination vehicles should be accelerated.

It is hoped that the writer's opinions may be considered as a simple basis of discussion, to take place initially between ourselves, the interested parties and then with the authorities, with whom collaboration is necessary, in order to find a generally satisfactory solution.

The Road Network and the Vehicle

The conversations which the writer has had with the prominent international transport companies in Italy have pointed up the fact that the success of future trucking operation —implying transit through roads of various nations—is related primarily to the solution of two important problems :

(*a*) uniformity on administrative rules ;
(*b*) uniformity on technical rules.

The most serious problem, under present circumstances, appears to be the first one, as purchasers of vehicles have to overcome many difficulties arising from transit authorisations, customs clearance and tariffs.

Whilst administrative problems are not, primarily, the concern of this paper, it is nevertheless felt that commercial vehicle manufacturers are interested no less than their customers in removing administrative obstacles, it being self-evident that if a vehicle cannot operate at its utmost design efficiency owing to administrative difficulties, it becomes more or less inefficient as a vehicle.

For this reason we shall consider technical problems (including difficulties caused by bulky vehicles to other road users, and problems of general traffic safety) in order to give manufacturers and operators some important elements which can be presented in support of their own proposals. If the foregoing problems are disregarded, the risk is run of favouring other transportation methods and systems.

We belong to this Continent. Here, our industries are operating, and our trade is located. Therefore, the characteristics of the intercontinental vehicle should be selected according to the conditions under which we must operate.

The Declaration on the Construction of the Main International Traffic Arteries, signed in Geneva, under the auspices of the U.N. Economic Commission for Europe on September 16, 1950, and successive amendments has agreed about a network of international itineraries, reaching through Turkey and the Near East, and in addition a minimum of technical specifications of the roads comprising such a network. The International Arteries are classified under the following categories.

A—Ordinary Type Roads.—Category I : Roads having a single carriageway, with two traffic lanes at least 11ft 6in wide.

Category II : Roads having more than two traffic lanes each at least 11ft 6in wide.

B—Motorways.—As this seems to be the best we can do for our international traffic vehicles, the question is how to get the most out of this road system for intercontinental transport.

This kind of operation cannot admit of any guesswork ; it must depend on a very efficient commercial organisation planned for increased business volume, plus the planned activity of agents, warehouses, arrival and departure stations, garages and repair shops, in order to maintain the perfect functioning of the vehicle operating some distance from service centres. The cost of operating this organisation should be kept correspondingly low as the weights of transported goods increase and this cost should be reduced when fewer vehicles are operating, that is to say, the goal should be higher pay-loads per individual vehicle.

It is apparent, from this outline, that the single unit truck cannot be considered as efficient for this kind of activity. Intercontinental transportation should be entrusted only to combination vehicles as defined at the Conference of Road and Motor Transport held in Geneva, 1949.

" A combination of vehicles may be composed of a drawing vehicle and one or two trailers. An articulated vehicle may draw a trailer . . . "

Let us consider an articulated vehicle as being also a " combination " in which case, the following are open to consideration :

(*a*) the articulated vehicle
(*b*) the articulated vehicle with one trailer
(*c*) the combination of vehicles with one trailer
(*d*) the combination of vehicles with two trailers.

If we consider that at previous discussions in international meetings there has been a growing tendency to limit the length of combinations, it might be concluded that any programme to utilise combinations for our transportation system would end in certain defeat.

If we admit that in the arguments presented during discussion, the combination length is of prime importance, we must agree that the authorities are completely right when they point out that overall length of combinations involves a question of danger, having regard to such safety factors as combination performance on cornering, and in the time necessary for overtaking.

At all events, we must consider the validity of these arguments. An example would clarify the problem. It is well known that the United States of America, in a huge Federal programme, are constructing 40,000 miles of super highways covering the entire country with a network that may be admired as the most progressive and modern system ever developed by any country. (Incidentally, may not this question be addressed to our Continental Authorities : " Why have the United States allotted to roads—and therefore to automobiles—such a large proportion of the national income ? ") The specifications of such super highways have led to an enlargement of the limits of combination length and weight in some States, so as to enable them to utilise to the fullest extent the advantages of the new highways which in turn benefit the community. New York State, leading the way, has permitted for super highway traffic the combination vehicle length of 98ft, with 127,000 lb G.C.W., embodying tractor, semi-trailer (40ft long) and full trailer, also 40ft long.

However, to these lengths and weights we should pay little attention, because the most interesting feature is that the combination, semi-trailer and full trailer has been designed so that the full trailer at the end of the super highway can be separated from any combination and picked up by another tractor. Thus, two separate articulated vehicles can be constituted which then may easily proceed to their destination through even the most congested network.

This simple device grants to users all the advantages brought about by highly modern road types, without any reciprocal disturbance. This conception should be given consideration by our Continental Authorities. Unfortunately, when discussing or developing international and national regulations, combination limit of length is considered as though motorways were neither in existence nor increasing yearly in number and development. In addition, neglecting the plan for ordinary size road evolution signed in Geneva in 1950-57, it seems to the writer that there is a tendency to enforce discrimination which would endanger road users, whose activity is after all of paramount importance to production and distribution undertakings.

It is the writer's belief that in the future the Regulation of intercontinental transportation should take account of both length and Gross Combination Weight (G.C.W.) as a functional road characteristic. This relationship should be more closely considered as technical road characteristics vary over a wider range, as we have seen.

As pay-load and adaptability are the basic features of the articulated vehicle with one trailer, it is the most suitable for our transportation pattern. It allows for a safe, courteous and wise utilisation of the most modern motorways ; divided into two articulated vehicles it becomes the familiar everyday vehicle, fit to load and unload at farms, small shops or warehouse courtyards. The same may be said of combination vehicles with one trailer when it can be transformed into a semi-trailer.

Our description of combinations also covers the two-trailer type. In principle it embodies the advantage of the articulated vehicle with one trailer but as it may need as many as three motor vehicles to haul the load, with the consequent disadvantage of operating two excessively short semi-trailers, this combination will hereafter not be considered, although it might be successfully used in some cases.

If our considerations about the articulated vehicle with trailer are based on its efficiency and the possibility of maximum utilisation of the road characteristics without inconvenience or danger to other users, another reason suggests itself for using the writer's preferred vehicle for long transportation hauls.

As, at present, it is customary for many shippers to collect and deliver to customers through agents and branch offices established in various countries, long distance transportation should also surely be organised on the basis of the same operational system.

This approach would be sound because our trailer and semi-trailer as a whole, in combination, or as two articulated items might be transported to their destination by tractor vehicles belonging to different concerns according to the peculiarities of their own branch transportation. Thus, the entire combination, to be powered by a 6×4 tractor through both flat country and mountainous routes, when divided, needs for the semi-trailers, 4×2 tractors. Such an operational system, which is already a well known railway technique, will lower costs and increase transportation and traffic safety.

Before specifying any set of rules designed to improve and enhance intercontinental transportation, it might be suggested that the conditions for the highest performance of the articulated vehicle with one trailer—hereafter briefly referred to as three-element combination—will be present only if the trailer and semi-trailer have the same length and pay load ; in addition, both must offer the possibility of conversion into either one or the other, by simply adding or removing a dummy axle.

Regulations

In 1949, a conference was held in Geneva, to establish regulations for Automobile International Transport. In addition to setting traffic rules and road signs, the delegates of the numerous nations participating in the meeting could obviously not overlook setting the weight and dimension limits necessary for vehicle construction. Such limits are listed in Tables I and II, together with those in force in Great Britain, in the German Federal Republic, in 1958, and subsequently modified in 1960, and those of France and Italy.

To complete this outline of the international regulations, it is necessary to add that the European transport ministers are discussing the possibility of enforcing new limits of weights and dimensions, which figures are not contained in the tables because they are the same as those of the German Federal Republic rules of 1960.

Table I

Overall dimensions	Geneva, 1949	G.B.	D 1958	D 1960	F	I
Height	150in	N.L.	157in	157in	N.S.	157in
Width	98in	96in	98in	98in	98in	98in
Length :						
Two-axle vehicles	33ft	30ft	33ft	36ft	36ft	33ft
Three-axle vehicles	36ft	30ft	33ft	39ft	36ft	36ft
Four-axle vehicles	—	30ft	—	39ft	36ft	36ft
Trailers	like vehicles	22ft	like vehicles	like vehicles	like vehicles	24ft 7in* 26ft 3in†
Articulated vehicles	46ft	35ft	43ft	49ft	46ft	46ft
Combination of vehicles with one trailer	59ft		46ft	54ft	59ft	59ft
Combination of vehicles with two trailers	72ft	N.P.	N.P.	N.P.	N.P.	N.P.

* = Two axles. † = >Two axles. N.L. = No Limit. N.P. = Not permitted. N.S. = No specification.

Table II

Weights (lb)	Geneva	G.B.	D 1958	D 1960	F	I
More loaded axle :						
Trailing	17,600	20,160	17,600	17,600	28,600	22,000
Driving	17,600	20,160	17,600	22,000	28,600	22,000
Tandem axles	32,000	40,320	26,400	35,300	46,300	32,000
Two-axle vehicles	38,600	31,360	26,400	35,300	41,900	30,900
Three-axle vehicles	49,600	44,800	39,700	48,500	57,300	39,700
Four-axle vehicles	—	53,760	—	48,500	57,300	48,500
Articulated vehicles	61,700	44,800(a) 53,760(b)	52,900	70,500	77,200	70,500
Combination of vehicles with one trailer	68,900	71,680	52,900	70,500	77,200	*
Combination of vehicles with two trailers	79,900	N.P.	N.P.	N.P.	N.P.	N.P.

* Sum of component vehicle weights. (a) Three axles. (b) Four axles.
N.L. = No limit. N.P. = Not permitted. N.S. = No specification.

These new limits, compared with those of Geneva, 1949, point out that according to length, the single unit vehicle and the articulated vehicle length has been increased by 3ft 4in, whilst the combinations of vehicle with one trailer have been shortened by 5ft. The combinations of vehicles with two trailers are not even considered.

As for weights, the European transport ministers' limits approximate those of the Geneva conference, with the exception of the articulated vehicle limit which has increased from 61,700 lb to 70,500 lb.

Fundamentally, between the two international regulations there is the following difference : whilst the Geneva delegates duly considered the combinations (so that none was neglected), and attributed increasing weights to increasing lengths, the transport ministers have put all combinations in a position of true inferiority with the elimination of the three-element combination, the reduction of length of those with one trailer and equalising their G.C.W. to the value proposed by them for the articulated vehicle.

It is apparent that if the weight limits of the European transport ministers should be definitely accepted, the future of intercontinental transportation will be impaired, because with the solely articulated vehicle (the only one favoured by the last International Authority), only traffic on short hauls will be possible.

Fortunately, the limits set by the ministers of transport are not yet in force. Even though they are the same as the limits adopted by the German Federal Republic in July, 1960, it is important to know that the Government Party itself expressed the opinion that in spite of the fact that the limits set were approved by Parliament, international contacts should still be maintained to arrive at further agreements about such matters.

Consequently, the discussion is still open, and because of the importance of the future of intercontinental transportation, it must be permissible " on the great international traffic roads " (Geneva 1949) to use the one trailer vehicle combination and the three-element ones. The writer will be pleased to illustrate hereafter an alternative proposal, for an international regulation embodying the transport ministers' fundamental elements, the Geneva 1949 Conference principles and some national regulations. Among the latter, consideration is given only to those belonging to the German Federal Republic, France and Italy because in addition to technical features of construction and circulation, the writer is acquainted also with those factors which could be considered as polemic, knowledge of which is so useful in order to understand the spirit of the national regulations.

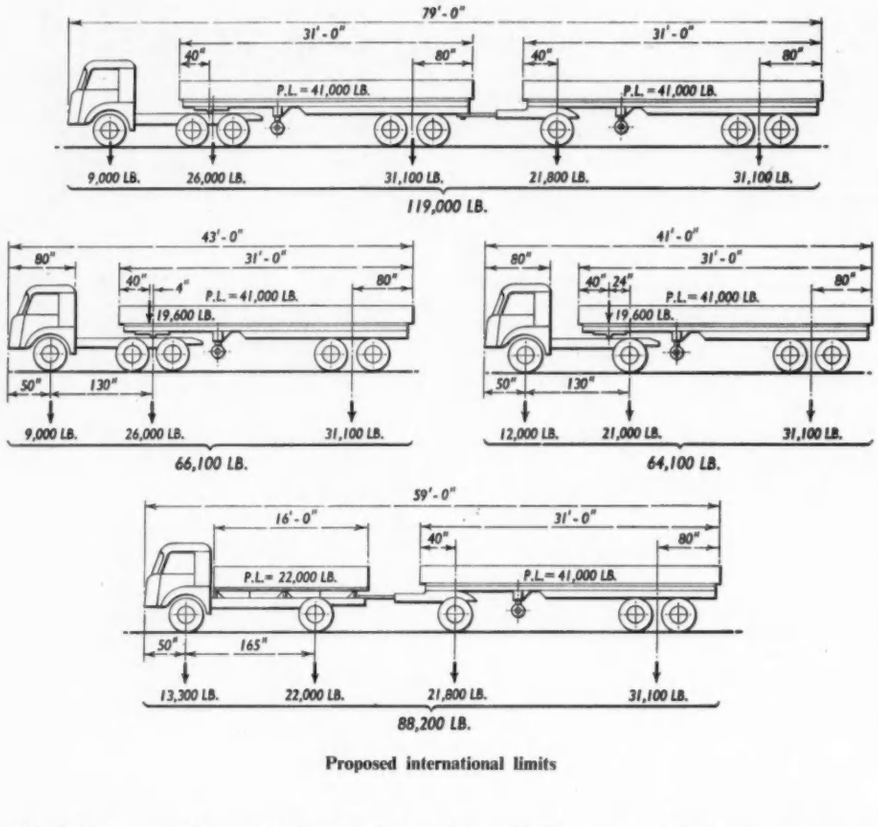
Let us begin with a discussion of dimensions by asking what the diagram (page 74) illustrates. It shows an articulated vehicle of 41ft length on a two-axle tractor ; another articulated vehicle of 43ft length coupled to a three-axle tractor ; a vehicle combination having one trailer; totalling 59ft length composed of one two-axle truck and one three-axle trailer; and, finally, one three-element combination, totalling 79ft overall length. It is very interesting to point out that all those various combinations utilise the same trailer, 31ft long.

To construct such vehicles and combinations, which are very useful for intercontinental transportation, it would be sufficient if the transport ministers were to decide to allow the vehicle-with-one-trailer combination a length of 59ft (proposed by the Geneva Conference of 1949), and agree to reconsider the use of the three-element combination with a total length of 79ft at least, for use only on motorways and not necessarily on all international traffic roads, as established by the 1949 Geneva Conference. If this new length limit of 79ft were to be considered objectionable because it is 6ft 7in longer than the one fixed for the same combination type at the Geneva Conference of 1949, it might be sufficient to think of its use as being limited to motorways, and to conclude then that such 6ft 7in additional length would not represent any danger for road users.

Finally, it might be pointed out that the proposed length limits of 59ft and 79ft would permit the loading of two British railway containers on the trailers 31ft long, provided that the above limits were to be specially increased, by about 1ft.

With regard to weight limitations, the writer's proposals are based upon the following modifications to the limits being discussed by the European transport ministers :

(a) In accordance with the Geneva Convention of 1949, the abolition of any distinction between trailing axle and driving axle, in order to set up the most-loaded-axle weight limit.



Proposed international limits

(*b*) fixing a specific weight limit of the three-axle trailers of 52,900 lb, as was permitted by the German Federal Republic until December, 1957.

(*c*) maximum combination weight to be specified according to length ; ranging from a minimum for the articulated vehicle to a maximum for the three-element combination, as per the Geneva Convention in 1949.

(*d*) acceptance of the Italian regulation principle, fixing the combination weight as the sum of the various weights of the component vehicles, the articulated vehicle being, in this respect, considered as a single vehicle.

Vehicles illustrated are examples of these possibilities.

Total weight, weight division both on single and tandem-axles, and pay-load, lead to the following considerations :—

(*a*) the pay-load of trailed vehicles is always the same, about 41,000 lb.

(*b*) the maximum load on tandem axles is always much less than the maximum limit fixed by the transport ministers.

(*c*) the maximum weight of articulated vehicles taking place from the three combination elements is also lower than the limit proposed by the same authority.

This having been established, the modifications to be made to the European transport ministers' weight limits would be as follows : on the most loaded axle 22,000 lb ; three-axle trailer 52,900 lb ; combination of vehicles with one trailer 88,200 lb ; combination of vehicles with two trailers 119,00 lb.

The one trailer vehicle combination of 88,200 lb total weight was very popular in Germany until December, 1957. It was normally composed of one two-axle truck and one three-axle trailer respectively of 35,300 lb and 52,900 lb weight, but the German operators had to give up such combinations, when, in January, 1958, the absurd limits of a 1954 law were applied. These are the same limits which the German authorities propagated in international meetings with the same conviction and decisiveness which is being employed by them in support of the new limits enforced in July, 1960.

Finally, if it is still considered objectionable to propel an 88,200 lb G.C.W. featuring a single driving-axle loaded 22,000 lb, let us cite the fact that in the Continent, during and after the war, an experiment which cannot be questioned was conducted when, owing to the inefficiency of the railway system, the German and Italian Government authorised the coupling of two trailers to one truck fitted with one single driving axle.

The limits of this proposal of the writer's are listed in Table III.

TABLE III

Overall dimensions		Weight (lb)	
Height	157in	More loaded axle ...	22,000
Width	98in	Tandem axles... ...	35,300
Length :		Two-axle vehicles ...	35,300
Two-axle vehicles	36ft	Three-axle vehicles	48,500
Three-axle vehicles	39ft	Four-axle vehicles...	52,900
Four-axle vehicles	39ft	Three-axle trailers...	52,900
Trailers	Like vehicles	Articulated vehicles	70,500
Articulated vehicles	49ft	Combination of vehicles with one trailer	88,200
Combination of vehicles with one trailer	59ft	Combination of vehicles with two trailers...	119,000
Combination of vehicles with two trailers	79ft		

It is hoped that this table has made it clear that the bases for the suggested amendments are :—

(*a*) to return to the basic principles of the Geneva Conference of 1949.

(*b*) The vast experience of design, manufacture and operation of vehicles gained by the various Continental nations during recent years should not be disregarded.

(*c*) to reconsider the three-element combination, as considered at Geneva in 1949, at least on motorways.

(*d*) to consider the progress that the construction techniques in both vehicles and road systems have brought about during these last ten years.

Arising from the above, the writer believes that the new limits are suitable as a basis of discussion with the Authorities, especially if we consider that the weight limits the writer has proposed, are within the " basic " values, as the tandem axle loads and the G.C.W. of the articulated vehicle.

Should such limits be accepted, they would bring the international transportation field once more into the bright atmosphere of Geneva, which buoyed up many hopes, and which unfortunately vanished as soon as national regulations were promulgated after 1949. In addition, they would ensure to international transport a profitable activity to the community, for which the rules now being discussed by the European transport ministers certainly hold no promise.

STANDARDISATION

For several years the International Standardisation Organisation (I.S.O.) has been studying the standardisation of the towing organs between tractor and semi-trailer, and between lorry and trailer.

If aid is to be given to the development of intercontinental transportation, it is necessary that the work of the I.S.O. should be completed as soon as possible.

The fundamental elements to be standardised are :

(*a*) the minimum ground clearance of the fifth wheel, as a function of tyre diameter ;

(*b*) the operational design diagram of the automatic and continuous braking system ;

(*c*) the electrical system voltage ;

(*d*) the electrical and pneumatic connections between vehicles ;

(*e*) the towing hook between lorry and trailer.

Personally, and from a technical standpoint, the writer cannot perceive any obstacles to the complete standardisation of the foregoing elements ; it is simply a matter of goodwill which must be assumed by manufacturers and users, even if some sacrifice is involved.

How can we expect to secure larger utilisation of our automotive potential, if in addition to administrative difficulties, and the drawback of the differences in national regulations, the manufacturers also add the impossibility of coupling the vehicles manufactured in our continental area ?

From a technical standpoint, no difficulty can be foreseen. On the contrary, the advantage, for instance, of standardising the electric-system voltage at 24V both for engine starter motors and illumination (as already effective in Britain and in Italy), may be more widely followed as it brings about cost reductions and reduced maintenance expenses : a simple amount of thought to accumulator batteries or to series-parallel switches of a 12V-24V electrical system, suggests that complete agreement might be reached.

As soon as this first objective has been reached, other elements of our automotive construction might be considered as possibilities for standardisation of size and performance. Examples are the accumulator batteries, the starter electric motors and the dynamos.

Unless all the items to which standardisation can be applied are standardised, road transportation (especially long distance) will suffer under extremely unfavourable conditions. In our capacity as manufacturers, therefore, we have to persuade our suppliers to reach operative agreements in every branch of continental industry, without fear of commercial loss because, according to the vast experience acquired during the past years, standardisation generates profitable business.

TECHNICAL SPECIFICATIONS OF VEHICLES

This last part of the paper will specify the three-element combination vehicle which is of fundamental importance to international transport, especially when the three-axle truck is considered.

Part I.—It will be necessary, however, first to list some of the requisites of vehicles with reference to the specific application for which the vehicle is constructed.

Basically, such requisites are related to truck combinations which perform long hauls. Such runs, performed under severe conditions, may take the combination far from a regular service centre, and consequently, any servicing other than at a regular service centre, should be so simplified and so minimised that the driver can perform it with no more than ordinary helpers. Even if the foregoing operations are related to the efficiency of the vehicle's assemblies, some design particulars, developed, for instance, to reduce the motor/chassis lubrication, would be both welcome and necessary. As a matter of fact, the relevant materials of modern construction such as rubber and derived products, plastic self-lubricating bushing, &c., may almost eliminate the lubrication of all control and suspension articulations. These applications could, for instance, eliminate certain fluid remote-controls, such as the clutch hydraulic actuation which, although appealing as a design, would, nevertheless, require periodic inspection.

As the adjustment of brakes, especially the clearance between liner and inner drum surface, takes rather a long time, the complete sixteen-brake combination should be equipped with automatic adjusters.

Design should also be utilised to cut down the time of scheduled shop maintenance. For example, the replacement of the water pump, dynamo and fan belts, as a rule requires radiator disassembly, a time consuming operation. This maintenance operation could be much facilitated if the radiator, rotating around an axis, were to free the engine front end, thus allowing an easy engine servicing of all front assemblies, and incidentally easy belt replacement.

Easy accessibility of components would allow for more accurate inspection of all devices that need frequent checkup. Thus, positioning of batteries should allow for easy inspection ; the same holds true for the braking system adjustment and the electrical equipment, especially fuses.

In addition to the foregoing details, which may be termed fundamental design items, a solution that might be more seriously considered in the future and applied to the reduction of both maintenance time and cost is the tilting cab. It further deserves consideration because the tractor of our combination, to be as short as possible, must be a forward control vehicle. The tilting cab undoubtedly represents the best design for easy engine maintenance. Personally, the writer is inclined to think that the additional cost and weight involved in this design could be largely compensated by the advantages that this adoption would afford. To be able to work standing on the ground and having within reach all engine components as though the engine were installed on a workshop rotary-stand, is certainly more comfortable and useful than working inside a cab.

This solution gives rise to yet another advantage. Such a cab being not in need of removable components which rest upon the floor in order to allow engine inspection, may be of more sturdy construction and, in addition, more useful as far as engine noise insulation is concerned in reducing fatigue. A tired driving crew must rest, and thus fatigue reduction would mean less stoppages and therefore increased commercial efficiency.

A further fundamental characteristic of intercontinental runs is the need for the crew to tolerate variable climatic conditions as though all the four seasons of the year had to be met with during the running time ; therefore, the cab should be equipped with heating and air conditioning facilities. A cab thermal insulation system including a large windshield surface, would assist in the enjoyment of the advantages of these artificial climatic conditions whenever the crew are resting during the turn-round shift.

Cab design should provide front visibility along the road ahead together with side and rear views ; in addition easy access to controls and check instruments, which the writer is inclined to think should be by means not of dial readings but of well located alarm lights to give easy signal detection even in full daylight, thus avoiding the necessity for the driver being distracted by periodic checks while driving.

Intercontinental transportation does not require an easy accessibility to the driving seat, this being not a door-to-door service. Nevertheless, even for the vehicle type we are considering, such a possibility must not be disregarded, for the less our vehicle differs from a conventional one, the more easy and profitable it will be to sell it, when it becomes obsolete for international transport. In this particular case we are speaking only of a three-axle tractor that could be utilised by contractors who desire a tipping body or for transportation of concrete mixers since those contractors well appreciate engine horsepower, liberal transmission and sturdy general design of the tractor.

Any long-distance time-table should be so planned as to allow the driving crew after their work shift to stop for board and rest in suitable centres, while the combination proceeds through the remaining itinerary. Nevertheless it is appropriate that the cab be provided with at least one berth so that one driver can rest, while another crew member substitutes (some countries prescribe two drivers for the combination).

The combination braking system, of the continuous and automatic compressed air type, will produce braking on each axle in due time, to avoid the jack-knife effect of the combination vehicles as retarded braking of farther axles is taking place. The various brake manufacturers offer a range of good solutions to this problem. Nevertheless to all manufacturers of trailers the abundant size of compressed air pipes and HD wheel-brakes will constantly be recommended.

What can be said about the safe operation of the braking system? Much controversial discussion abounds both about Continental and American opinion. There are supporters of the individual axle-unit protection system and of individual vehicle protection ; some technicians suggest vehicle automatic braking as the compressed air pressure is under certain limits and others are opposing any activation if not granted by driver's control.

The writer's view is that braking safety fundamentally originates from precise maintenance. In addition, the braking system design should be as simple as possible and be so connected that vehicle-by-vehicle protection could be secured.

As a simple basis for discussion one might suggest instituting the control of the braking of the two trailers from the two sections of the tractor brake system or with actuation by the driver of a three-section brake valve ; one section for each combination vehicle would facilitate the braking timing of each component. This also includes the possibility of actuation by the driver of the emergency brake embodied in the automatic section of the braking system.

Generally the trailer vehicles should be " air spring " suspended, because :

(*a*) after an experimental period it has been proved that " air springs " have the comparatively good characteristics foreseen by advanced designers ;

(*b*) they offer longer suspension life than leaf springs ;

(*c*) oscillation of the air spring suspended vehicles, both loaded or empty, becomes comparatively reduced, thus allowing fundamentally important weight reduction of stressed sections, to the advantage of increased payloads ;

(*d*) axles may be articulated to the vehicle without need of assembly lubrication.

Air springs may be applied also to the three-element combination tractor ; the writer's opinion is that, nevertheless, tandem-axles might be advantageously suspended on leaf springs, because they are more self-contained. In addition, it is considered that air springs are equally advantageous for front wheels which should have independent suspension, fitted with coupling articulations needing no lubrication.

The reduced load of the three-element combination truck front axle does not need power-steering although it is generally useful. However, it is necessary only when steering conditions require excessive driver effort, which derives from front axle ground reaction of more than 10,000 lb to 11,000 lb.

This enumeration of chassis construction characteristics cannot end without proposing tyres of minimum size, according to their load capacity. The most loaded axle weight being limited to 22,000 lb, a two-axle vehicle with a 35,300 lb G.V.W., needs 11·00–20 Extra HD size tyres. Owing to the fact that our three-element combination trailers may be connected to this truck, it is convenient that both trailers and truck be fitted with tyres of the same size.

As the proposals of the European transport ministers may be criticised from a technical viewpoint, additional argument could be, for example, the possibility of adopting 10·00–20 Extra HD tyres for all our combinations, two-axle truck and tractors, provided that the most loaded axle weight would be increased from 22,000 lb to 23,200 lb with the following advantages :—

(*a*) greater pay-load for less tyre weight ;
(*b*) higher load space, due to less tyre diameter.

Part II.—We shall now discuss the propulsion mechanism of the combination truck/tractor ; engine, clutch, gearbox, and rear axle.

National and international goods transportation in our Continent is strictly geared to the development of the high speed diesel engine. Perhaps it is proper to state that the continuous growth of industrial transport is due to the uniqueness of the diesel engine, so well known to us and so successfully developed by all manufacturers. An examination of the diesel engine technical features leads to the conclusion that all manufacturers have secured a promising reduction of the specific weight (per h.p.) this being derived from two important elements ; combustion chamber development and engine crankshaft speed improvement.

Conventional series production, keeping cost in mind at all times, obtains for the four-stroke water-cooled engine, a specific weight ranging from 10 lb to 8 lb according to engine speed. If to the foregoing advantages we add the much reduced specific fuel consumption and very high brake mean effective

pressure, which the modern engine models are obtaining, we could agree on the advantages of diesel engined propulsions to our three-element combination.

How much horsepower should this motor develop? In reply, two elements must be considered :

(*a*) The maximum speed of the combination ;

(*b*) The minimum speed that the combination should maintain on given slopes, in order to avoid too much speed reduction through hilly districts.

The second point is already covered by some regulations which, for example in the New York State, require 20 m.p.h. on 3 per cent gradients. The same concept was followed by the German Federal Republic regulation by the 1954 law, which required a minimum power of 6 h.p. per 2200 lb of G.V.W. or G.C.W., in order to secure a speed of not less than 9·3 m.p.h. on 6 per cent gradients.

As is generally known, German regulations were much discussed, probably because the engine outputs were, in those days, far less than the legal limits. The writer feels the Authorities are perfectly correct when they require that heavy industrial vehicles must develop a speed which will not excessively check any following vehicles even when on winding, hilly roads. We have considered 70,500 lb of G.C.W. for the articulated vehicle, 88,200 lb for the one-trailer vehicle combination, and 119,000 lb for two-trailer vehicle combination. According to the German rule, the horsepower corresponding to the three above combinations should be 192, 240 and 324 respectively.

Such power rates would secure speeds respectively of 47 m.p.h., 50 m.p.h. and 53 m.p.h., assuming that the combination front surface is 96·8 square feet, when considering that trailed vehicles have van type bodies (better if open top) which is possibly the most appropriate to our intercontinental transport.

If we start our investigation at the point of minimum power required to climb 6 per cent slopes, which also allows for good maximum speed, increasing with the operating importance of the combination vehicles, we may establish two points ; the first one concerns the engine output and the second the design of such engines. According to the writer's experience, maximum engine power must be 15 to 20 per cent more than the power required to run the combination at maximum speed, if mileages of 350,000 between general overhauls is to be expected. Consequently, the horsepower cited above should be increased to 230, 285 and 390 respectively. Although in our Continent we have not yet a very advanced and safe knowledge about field engines exhaust-gas supercharged, one feels that the foregoing power-rates are to be obtained expressly by engine supercharging in order to reduce specific weight and during normal vehicle operation specific fuel consumption as well as thermal stresses.

Which design will such engines feature? Cylinders in line, or "V" cylinder-block? If we examine power rates and the modern possibilities of the high speed diesel engine design of sufficiently long life, we find that up to 300 h.p. with the aid of supercharging, can still be relied upon from six cylinders in line. Greater power, such as is necessary to run our 120,000 lb three-element combination, would necessitate "V" engines of eight or twelve cylinders simply to extract out h.p. from r.p.m. The writer believes there is no problem in mounting a "V" engine within a forward control cab provided it tilts.

It is superfluous to deal with particular design characteristics of the engines, because, as indicated above, manufacturers nowadays have a wide experience, as far as functioning, long life and maintenance are concerned.

Next we should discuss the clutch, gearbox and rear-axle head assembly. It would be excessively optimistic to consider only conventional dry-disc clutch and gearbox for a power of about 400 h.p. with which we are dealing. No doubt, this would be suitable for powers of about 300 h.p. to 350 h.p. and G.C.W. up to about 92,000.

Powers and weights in excess of the foregoing, which are present in three-element combinations, give rise to a delicate problem of design for our vehicle, namely the transmission of power from engine to wheels. The solution could be obtained by hydraulic transmission, either as simple fluid-flywheels or complete torque converters, both fitted with mechanical gearboxes which, for sake of simplicity, should preferably be of the epicyclic type : the writer is in favour of the latter solution, because transmission strains are much reduced, especially when starting the vehicle or gear-changing.

In principle, the hydraulic/mechanical gearbox should produce a ratio reduction of 8 (in order to afford easy starting of the combination) divided between torque-converter ratio of 2 and gearbox first speed of 4. Naturally, the torque converter should be so designed as to embody a freewheeling stator, so that when the input and output torque are equal its operation is transformed in a fluid flywheel, with increased transmission efficiency.

The schematic solution described here for the transmission should not be considered exclusively ; others may be suggested and even, perhaps, some of classic design, as we shall see when discussing rear-axles. At all events, the clutch pedal should be abolished ; moreover, finger tip control, if possible, or at least a power-control, are to be considered as a contribution to the reduction of a large part of driver fatigue.

The next subject for discussion is rear axles and deals principally with their head-assemblies. No difficulties will be experienced as ground reaction for each axle is near the 14,500 lb mark approximately, and since no high strain is produced, only normal design of rear-axle types should be applied.

Having chosen a maximum speed of about 53 m.p.h. for the combination, with tyres 10·00–20 and engine r.p.m. of 2400, the rear axle ratio could be about 5·4. This is rather convenient for good-efficiency, long life for the worm drive, and secures the simplest solution for driving tandem axles especially when a front differential may be advisable.

In addition, if we were to use two-speed rear-axles (very popular in the United States and lately introduced into our Continent) it would perhaps be advantageous to consider the constant-mesh synchronised gearbox, in order to secure a transmission possibly cheaper than the previous one and certainly cheaper in operation. For instance, a two speed rear-axle with 5·57 high-ratio and 7·6 low ratio, may obtain for our combination something in the region of the above performance with a gearbox having top gear 1 : 1 and low gear 1 : 5·8. The possibility of featuring a mechanical gearbox with a total reduction ratio of 5·8 represents an advantage as the engine inlet torque will be as high as about 900-975ft-lbs. This gearbox could operate in either one of two ways ; one allowing four and the other five gear ratios.

The first solution suggests the interesting possibility of equalising the four ratio steps since these could be split by the rear axle ; thus signifying that the combination would be provided with eight speeds with constant steps of about 1·36. This solution is certainly inviting ; nevertheless if all eight steps should be worked when accelerating or climbing or descending gradients, the axle shifting would be rather frequent, and would increase driver fatigue. To reduce this fatigue the five-speed gearbox could be used.

A good utilisation of the engine power could follow with five speed low range and five-speed high range. By utilising the first one for starting and for hill districts and the second one for flat roads, we reduce to a minimum rear-axle shifting. As far as rear-axle shifting is concerned, there is an intermediate solution related to the five speed gearbox. Let us consider again the foregoing five-speed gearbox with the following ratios : First 5·8—Second 3·22—Third 1·79—Fourth 1·34—Fifth 1 ; with a step of 1·36 between high and low in the rear axle it is possible to split—first/second and second/third in the gearbox to obtain eight speeds again. The same splitting may be produced, without any basic change, between fifth and fourth and between fourth and third speeds.

The conclusion which may be drawn from examples in which a conventional type gearbox is coupled to two-speed axles, is rather encouraging providing the clutch problem is resolved in an adequate manner. If one may repeat the conviction that the starting of a combination equipped with a dry-disc clutch might impair either the clutch or the synchronisers, it could be added that a possible solution is the addition between engine and clutch of a low loss fluid flywheel.

The writer has had the pleasure of developing what would be his programme if he were to begin to design the intercontinental vehicle which he has had the opportunity of defining. All the suggestions are related not to specific knowledge in this field, but to our wide experience of the problems concerning combination vehicles, including a total weight up to 80,000 lb, which in Italy are very popular and have been considered since the end of the second world war to be the typical international transport vehicle for distances sometimes exceeding 2500 miles for the round trip.

Communication in Science and Industry

THE need for rapid communication between science and industry, enabling research results to be made known quickly and clearly to the widest possible technical audience, is the theme of a two-day national conference—"Science and Industry—The Problem of Communication"—to be held at the Brangwyn Hall, Swansea, on April 18 and 19. The conference is being organised by the Department of Scientific and Industrial Research, with the assistance of a local advisory committee under the chairmanship of Sir Maynard Jenour. Speakers include Dr. R. M. Lodge (Research Director, British Nylon Spinners, Ltd.) ; Dr. M. R. Hopkins (Senior Lecturer, Physics Department, University College, Swansea) ; Mr. W. S. Robertson (Chief Executive Officer, Scottish Council Development and Industry) ; Dr. D. J. Urquhart (Head of the D.S.I.R. National Lending Library for Science and Technology) ; Mr. Percy Cudlipp (Editor of *The New Scientist*) ; Mr. Edgar Anstey (Chief Films Officer, British Transport Commission) ; and Mr. L. W. Stevens-Wilson (Head of Steel Users Section, B.I.S.R.A.). Applications to attend the conference should be made to the D.S.I.R. Liaison Officer for Wales, Block II, Government Buildings, Gabalfa, Cardiff.

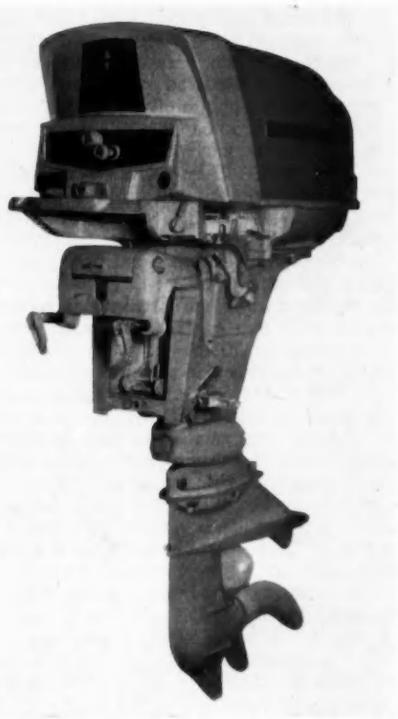
Engines at the International Boat Show

At the International Boat Show which closed on January 14 there was displayed, as well as a wide variety of small craft, a large number of power units ranging from the small outboard engines suitable for dinghies to turbo-charged diesel engines of large output.

Representative of the outboard engines was the "Bundy 500" manufactured by Bundy Marine of Milan which has a capacity of 497 c.c., a bore and stroke of 71·4 mm by 62mm, and develops 30 h.p. at 5200 r.p.m. The drive is by hypoid bevel gear transmission, having a ratio of 14 to 25, to a three-bladed light-alloy propeller, and the total weight is 103 lb. A submerged pump circulates the cooling water, and the fuel consumption at full power is 2·65 imperial gallons per hour. The Woodson 7D unit produced by Woodson Marine, Ltd., consists of a Hirth air-cooled, two-stroke diesel engine having a bore of 77mm by 96mm stroke, and a swept volume of 447 c.c. and a compression ratio of 22 to 1. At 2200 r.p.m. 7 b.h.p. is developed, the corresponding fuel consumption being 3·24 pints per hour. Power is transmitted from the engine, which is inboard of the transom, by twin vee-belts to the gearbox which has a vertical output shaft driving the propeller shaft through bevel gears. The three-bladed propeller of 13in diameter by 9in pitch has a maximum speed of 1000 r.p.m. Weight of the unit is 285 lb, the engine is mounted on bonded rubber mountings and the whole unit is pivoted on return hydraulic dampers.

F. Perkins, Ltd., in addition to its existing range, showed a new 40 h.p. outboard motor which has a downward directed silencing system. The unit, seen in our illustration, has a two-cylinder, two-stroke, water-cooled power head developing maximum power at 4500 r.p.m. and having a bore of 3¼in by 2⅞in stroke. There are forward, neutral and reverse gears and electric starting, and power is transmitted by a three-bladed propeller of 10½in diameter by 14in pitch. Also shown by the company were examples of its range of diesel engines and the 50 h.p. Perkins "Mars" gas turbine water pump of 500 gallons per minute capacity. Included was the P3/144 M engine having three cylinders of 88·9mm bore by 127mm stroke, a swept volume of 2·36 litres and a compression ratio of 16·5 to 1. The output ranges from 21 to 37 s.h.p. at 1200 to 2250 r.p.m. and weight with direct drive is 1002 lb.

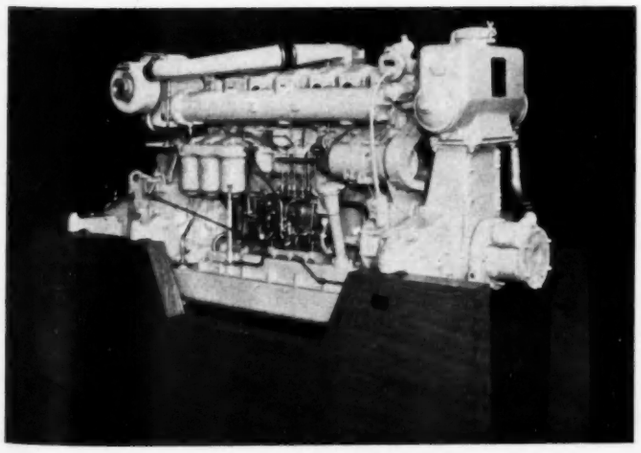
Crossley Brothers, Ltd., displayed a range of small marine engine units including a mark W.H.4 which is based on the Standard diesel engine. The engine has four cylinders of 3 $\frac{5}{16}$in bore by 4in stroke and a compression ratio of 20 to 1, and develops 42 b.h.p. at 2500 and 48 b.h.p. at 3000 and 3600 r.p.m. The cylinder is of high-duty cast iron cast integral with the crankcase and is fitted with dry liners, while the head is a unit casting incorporating Ricardo "Comet" V combustion chambers. Aluminium alloy pistons are fitted, and the connecting-rods are of manganese molybdenum steel and have large steel backed, indium flashed copper lead lined big-end bearings. Similar bearings carry the crankshaft. Fuel is delivered to the sprayers by a plunger distributor pump and a mechanical lift pump, and lubrication is by a gear-driven high-pressure pump, while cooling is effected by a heat exchanger. The W.L.4 engine has the same basic particulars but is designed to run at a lower speed and develops 27 b.h.p. at 1500 r.p.m.

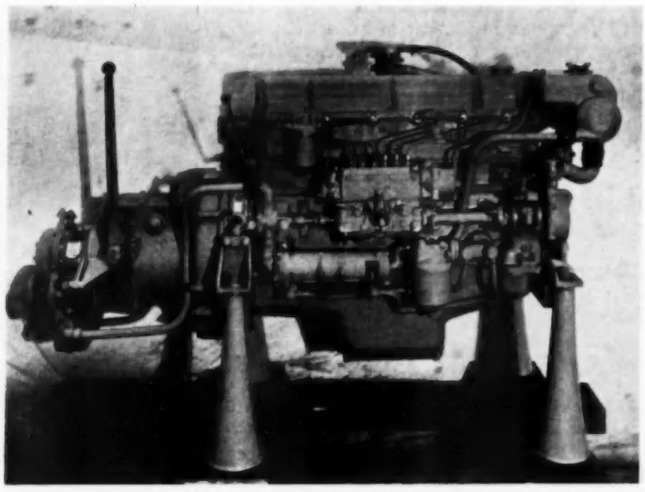


Perkins 40 h.p. outboard engine

On the stand of R.J.C. Motors and Marine Engines, Ltd., there were on view several G.M. diesel engines, including a four-cylinder lightweight unit and a six-cylinder Vee engine, both from the "53" series which has a bore and stroke of 3⅞in by 4½in and a compression ratio of 17 to 1. Also shown were marine units based on the Bedford four-stroke diesel engine, namely the R.J.C. 200 and R.J.C.300. These are respectively four-cylinder and six-cylinder engines having a bore of 3⅞in by 4¼in stroke, a compression ratio of 17 to 1, and a continuous rating at 2200 r.p.m. of 44 s.h.p. and 68·5 s.h.p.

The oil engine division of Rolls-Royce, Ltd., exhibited units typical of its range of diesel engines, there being four- and six-cylinder normally aspirated engines, a six-cylinder supercharged engine and two eight-cylinder turbocharged engines, together with a Mark IV six-cylinder turbocharged unit which we illustrate. This is a marine version of this recently introduced range of higher powered engines and is also available with four and eight cylinders. The four-stroke direct-injection engine is of monobloc construction with removable wet liners and has a bore and stroke of 5⅛in by 6in, a compression ratio of 14 to 1, and incorporates individual four valve cylinder heads and improved pistons to give extra power. This is estimated to approach 12½ per cent more than the two valve design and is coupled with up to a 7 per cent decrease in specific fuel consumption. The increased power has resulted from the improved gas flow to and from the combustion chamber by the use of four valves. which has also increased valve reliability. Fuel injectors of improved design are fitted, housed under the valve rocker covers, and there is an external injector spill system to avoid dilution of lubricating oil. Adoption of individual cylinder heads has reduced servicing time, while the new pattern pistons are of improved material, the top compression ring groove





(Above) Rolls-Royce Mark IV engine rated at 140 b.h.p. at 1000 r.p.m. to 256 b.h.p. at 1800 r.p.m. (Right) Thornycroft (Ford) RF6/D engine developing 50/86 b.h.p. at 1250/2250 r.p.m.

lying in a cast iron insert. The six-cylinder engine has a continuous rating of 140 b.h.p. at 1000 r.p.m. to 256 b.h.p. at 1800 r.p.m.

Both air-cooled and water-cooled units were displayed by Lister Blackstone Marine, Ltd., and included examples of the S.L.M. series of engines which are available with one, two, three and four cylinders. The SL4MG/R is a four-cylinder, air-cooled, four-stroke engine which develops 20 b.h.p. at 2150 r.p.m. and has a bore and stroke of $3\frac{3}{16}$in by $3\frac{1}{2}$in and a compression ratio of 22 to 1. Cooling of the engine, which weighs 660 lb, is by a single-stage, belt-driven axial flow blower and a rotary pump supplies lubricating oil under pressure, while fuel is delivered by individual C.A.V. "A" pattern pumps and a lift pump. The brake mean effective pressure is 67 lb per square inch and the specific fuel consumption is 0·50 lb per brake horsepower per hour: the engine, which has electric starting, has a maximum installation angle of 15 deg. The twin-cylinder model has a rating of $8\frac{1}{2}$ b.h.p. at 1800 r.p.m. Another air-cooled engine on view was a mark HB2 M.G.R. unit which develops 24 h.p. at 2000 r.p.m. with a brake mean effective pressure of 84 lb per square inch. The bore is 4in and the stroke $4\frac{1}{2}$in: the fuel consumption is 0·43 to 0·449 lb per brake horsepower per hour. Lubricating oil is supplied under pressure to all bearings by a rotary pump.

In the pool was a 30ft motor sailer/fishing cruiser built and engined by John I. Thornycroft and Co., Ltd., the engines being mark R.J.D.2. diesel units each rated at 16 b.h.p. at 1800 r.p.m., while on the stand was a 21ft pilot dispatch launch powered by a Thornycroft R.T.R.4 diesel engine of 40 b.h.p. The company also exhibited a number of its engines including an RF6/D unit, illustrated herewith, which is based on a Ford engine. As modified for marine purposes, the six-cylinder engine, of 100mm bore by 115mm stroke, has a cylinder capacity of 5·416 litres, a compression ratio of 16 to 1, and continuous power ratings of 50 b.h.p. at 1250 r.p.m. to 86 b.h.p. at 2250 r.p.m. The engine has a cold starting direct injection head, replaceable wet cylinder liners, a seven bearing forged steel crankshaft and thermostatically controlled closed circuit fresh-water cooling, together with a self-priming seawater pump with a rubber impeller. Net weight of the engine and reverse gear is 1252 lb and the maximum angle of installation is 12 deg.

On the stand of Parsons Engineering Company, Ltd., was an example of a Parsons Renk oil-operated marine reverse gear and various engines in the Parsons range, including a marine version of the Ford 105E "Anglia" engine. The four-cylinder, four-stroke o.h.v. petrol engine "Sea Urchin" has an installation angle of 10 deg., a compression ratio of 8·9 to 1, a bore of 3·185in and a capacity of 996·6 c.c. A Jabsco water pump is fitted and direct sea-water cooling is employed, the exhaust manifold being water cooled. At 1000 r.p.m. the s.h.p. is 7·5 and ranges to 37 s.h.p. at 4000 r.p.m., while the corresponding approximate fuel consumption is 0·60 to 2·5 gallons per hour. The engine is fitted with the company's new "Marinomatic" reverse gear type "C" which does not absorb any engine power and which uses a multi-plate centrifugal clutch for the ahead drive with an epicylic reverse gear engaged by hand.

Another reverse reduction gear to be seen was the oil-operated unit exhibited by Thames Marine Propulsion, Ltd. This self-contained, fully automatic, compact, hydraulically operated marine gearbox is available for direct drive or with built-in reduction gear incorporating two or three single helical gear trains. It is suitable for use with petrol or diesel engines developing up to 100 lb feet torque and for speeds up to 5000 r.p.m. A built-in pump supplies oil under pressure for actuation and forced lubrication: the high-pressure oil is directed by a control valve to act on either side of the operating piston, which is mounted on the clutch moving element. This is splined onto the planet carrier so that it may slide axially and when it is engaged with the external conical surface of the output shaft all rotating components are locked together to give ahead drive. At the other end of its travel the clutch moving element engages the astern clutch lining and the drive is transmitted through an epicyclic gear train formed by the sun gear on the input shaft, the individually rotating planet gears and the annulus gear formed in the output shaft. An adjustable built-in differential relief valve maintains the operating oil at constant pressure.

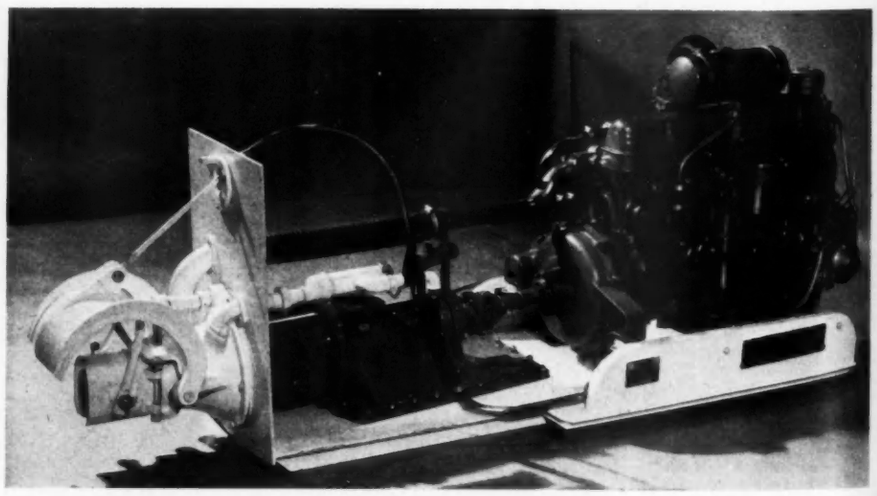
Eleven diesel and petrol engines including single-cylinder air and water-cooled diesels, horizontally-opposed, twin-cylinder, air-cooled and water-cooled petrol and diesel engines and a horizontally opposed, four-cylinder water-cooled petrol unit, were shown by the Coventry Victor Motor Company, Ltd. They were representative of the Victor engines and covered a power range from $2\frac{1}{2}$ to 33 b.h.p. In addition to the engines there was on view the Victor hydraulic forward/reverse/reduction gearbox having gear ratios of 1 : 1, 2 : 1 or 3 : 1. The gearbox, which we illustrate, is suitable for use with any engine with a maximum input torque of 70 lb feet at speeds up to 3000 r.p.m. and has a mechanical efficiency of about 95 per cent. The housing is of aluminium alloy and the shafts are of high-tensile heat-treated steel machined and precision ground, while the driving gears are of high-tensile steel and of special alloy iron. A duplex roller chain drive is employed, and double purpose deep groove ball bearings take the ahead and astern thrust, while for the gears there are pressure lubricated phosphor bronze bearings. Oil-operated cone clutches are used, one for ahead and one for astern, and the oil is supplied by a gear pressure pump, mounted externally and driven from the gearbox. The dry weight of the box is 130 lb.

Three-, four-, and six-cylinder models of the R.K. series, which has a bore of $4\frac{1}{4}$in by $5\frac{1}{2}$in stroke and a compression ratio of 18·5 to 1, and a power range of 30 to 60 b.h.p. at 1200 r.p.m. and 35 to 70 b.h.p. at 1500 r.p.m., were on show on the stand of Ailsa Craig, Ltd. These units now completely supersede the earlier mark R.F. engines. The company

"Victor" hydraulic gearbox

also showed mark R.L.1 and R.L.2 engines which are modified versions of the original R.F.1 and R.F.2 units. These engines develop 10 b.h.p. and 20 b.h.p. respectively at 1200 r.p.m. with a brake mean effective press of 88 lb per square inch, and have aluminium alloy pistons, high-tensile steel drop forged connecting-rods with four bolt pattern prefinished big-end bearings and a prefinished wrapped pattern small-end bush. The crankcase is a monobloc casting carried up to the cylinder heads, which are Meehanite castings incorporating Ricardo "Whirlpool" combustion chambers. C.A.V. pumps, injectors and fuel filters are fitted, and water circulation is by a gunmetal plunger pump driven by the camshaft.

Ajax Marine Engines, Ltd., exhibited examples of the Leyland/Albion engines, ranging from 30 to 275 b.h.p., and also the "Aries," another conversion of the Standard four-cylinder, four-stroke diesel engine. In this case the engine has a continuous rating of 36 b.h.p. at the governed speed of 2500 r.p.m.

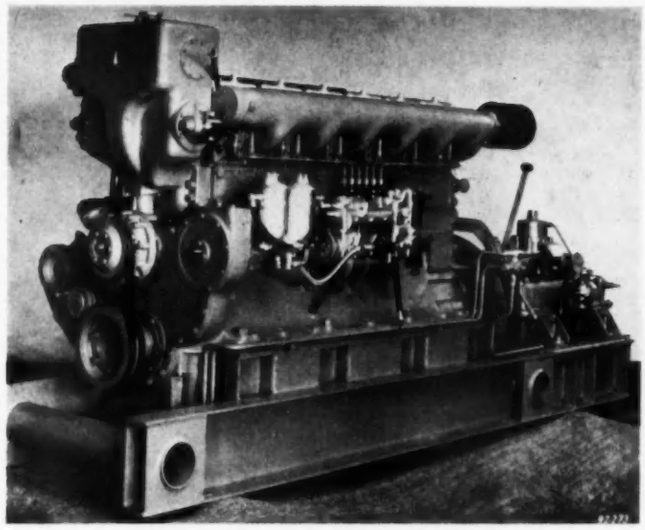


Dowty-Hamilton jet turbine unit powered by Ford "Zephyr" engine

Four engines representative of those produced by the Brit Engineering Company, Ltd., were shown and included the single-cylinder Brit "Minor" developing 4 h.p. at 2000 r.p.m., the twin-cylinder E.10 of 10 h.p. at 1100 r.p.m., the four-cylinder F.20 rated at 20 h.p. at 1100 r.p.m., and the B.D.2 twin-cylinder, four-stroke diesel engine. This unit weighs 650 lb, develops 10 b.h.p. at 1500 r.p.m., and has a bore of 85mm by 108mm stroke. The crankcase is in halves, the top half monobloc with the cylinders, while the bottom half carries the drop forged high-tensile steel crankshaft in steel backed white metal lined bearings. Wet liners are fitted and the engine, which has a torque of 42ft lb at 1500 r.p.m., has a fuel consumption of 0·4 pints per brake horsepower per hour.

Our illustration shows a Dowty-Hamilton jet turbine unit powered by a marinised Ford "Zephyr" engine which has been developed with the unit. Basically the jet employs the same principle as a propeller and receives a mass of water at boat speed and then accelerates the water to a higher speed so that the change in momentum produces the propulsive thrust. This is achieved by a high efficiency, two-stage, axial-flow turbo-pump which draws in water through a toughened steel grid and ejects the water aft to produce a thrust of 700 lb. The gate control and steering mechanism consists of a curved deflector and a pair of deflector plates, and going astern movement is accomplished by swinging down the curved deflector to direct the water under the hull. Two deflector plates acting on the jet stream act as a rudder.

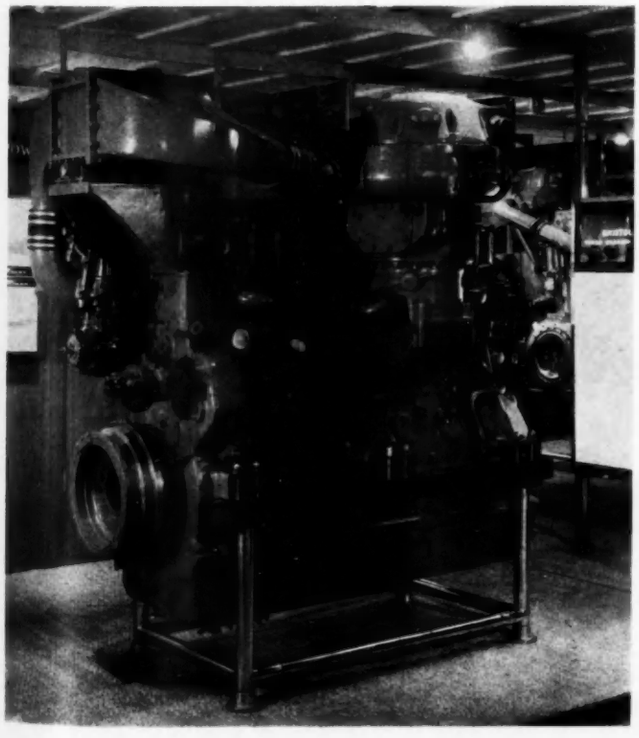
On the stand of Falmouth Boat Construction, Ltd., Watermota (1959), Ltd., displayed a number of engines including the "Sea Lion," based on the Triumph T.R.3 engine, the "Sea Scout" and the "Sea Urchin," based on Villiers air-cooled diesel and air-cooled petrol engines respectively. The "Sea Scout" weighs 160 lb, has a compression ratio of 24 to 1 and a bore of 2¾in by 2¾in stroke, and develops 4 b.h.p. at 3000 r.p.m. with a brake mean effective pressure of 64·5 lb per square inch. The fuel system includes a C.A.V. pressure pump and Pintaux nozzle injector, and lubrication is by a plunger pump, while the permissible angle of tilt is 30 deg. in any direction. On the stand Slack and Parr (Marine), Ltd., showed examples of its stern gear, and included a 24in diameter three-bladed, manually-operated, variable pitch feathering and reversing propeller intended for engines in the 40 h.p. to 80 h.p. range.



Mercedes-Benz six-cylinder Mark 846A engine developing 250 h.p. at 1500 r.p.m.

The marine division of the Excelsior Motor Company, Ltd. displayed "Seafarer" two- and three-cylinder petrol units, the former having a capacity of 328 c.c. and developing 10 h.p. to 15 h.p. at 4500 r.p.m., and the latter having a capacity of 492 c.c. and a rating of 28·7 b.h.p. at 4500 r.p.m. The bore and stroke is 58mm by 62mm. High quality close grained grey iron is used for the cylinders and aluminium alloy for the crankcase. The piston is of die-cast aluminium alloy, and the connecting-rod is a steel forging with phosphor bronze small-end bush and a hardened track for the double row roller big-ends. In the two-cylinder unit two ball bearings and three roller bearings carry the high-tensile steel case-hardened crankshaft. Cooling water is circulated by a water pump having a neoprene impeller and the maximum installation angle is 15 deg.

Among the larger engines to be seen at the show were those on view on the stand of Bristol Siddeley Engines, Ltd., which included Maybach MD.220 and MD.330 units as representative of a range of engines which includes eight-, twelve- and sixteen-cylinder Vee engines and which covers a power range of 360 to 2857 b.h.p. according to service. The MD.220 is a four-cylinder in-line unit which with the addition of an intercooler is to be installed in six trawlers. Our illustration shows the MD.330 turbo-charged and intercooled marine engine which has six cylinders in line and has a continuous rating of 592 b.h.p. at 1400 r.p.m. and a brake mean effective pressure of 170 lb per square inch when installed in small craft, and 680 b.h.p. at 1525 r.p.m. and a brake mean effective pressure of 179 lb per square inch for intermittent service in yachts. All the engines have a bore of 185mm by 200mm stroke and a compression ratio of 15·5 : 1. The pistons, which have detachable crowns, are pressure oil-cooled and the wet cylinder liners are surrounded by a uniform forced flow of cooling water: the cast iron cylinder heads, which have three inlet and three exhaust valves symmetrically disposed around an almost spherical pre-combustion chamber, are interchangeable. Each cylinder is provided with fuel injection units which combine a pump and injection nozzle.



Bristol Siddeley Maybach MD.330 turbo - charged and intercooled engine of 592 b.h.p. at 1400 r.p.m.

Four engines were exhibited by Mercedes-Benz (Great Britain), Ltd. They were the sixteen-cylinder Vee Mark MB 839 Bb. developing 2400 h.p. at 1500 r.p.m., the OM 321 six-cylinder engine rated at 94 b.h.p. at 2600 r.p.m., the four-cylinder OM.636 developing 35 h.p. at 3000 r.p.m., and the MB.846 A unit which can be seen in our illustration. This six-cylinder four-stroke diesel engine has a bore of 150mm and a stroke of 190mm and develops 114 h.p. to 250 h.p. at 750 to 1500 r.p.m. It has a cast iron engine block, wet liners, individual cast iron cylinder heads and one inlet and one exhaust valve per cylinder. The pistons are of light alloy and the connecting-rods, of heat-treated steel, have lead bronze bearings steel backed, while similar bearings carry the heat-treated and hardened steel crankshaft.

LETTERS AND LITERATURE

Letters to the Editor

THOUSANDS OF MILLIONS TO BE SAVED ?

SIR,—The reiteration, in your leading article of December 30, of the statement that railways can no longer be regarded as essential to this country is timely and important, since the whole basis of transport policy is still the now quite unjustifiable assumption that railways *are* essential. Whilst a false assumption of this magnitude prevails we shall continue to lack a transport policy which meets our needs, with all the dire economic and social consequences which this entails.

Your article concludes with the words, " The choice before them (the railwaymen) is to see the railways they serve die a lingering death or, gloriously, to revive their fortunes." Earlier in the article it was suggested that if the railways shrunk until not even a " rump " remained " The Railway Conversion League would rule triumphant as the railways would be converted, no doubt, into roads." The League, however, would derive no sense of triumph from the " lingering death " of the railways, for two reasons :

1. Contrary to belief in some quarters we have much sympathy for, and fellow-feeling with, railwaymen—we have railwaymen amongst our members—and want to see them enjoy the exciting and satisfying experience of taking part in the metamorphosis and revival of the railway network as part of the transport system of the modern age.

2. We fear that by the time the railways had dwindled to nothing great chunks of their permanent ways and other property would, under the new " commercial freedom," have been sold off to bolster inadequate income and the priceless network of through-routes now existing would no longer be available as the basis of a reserved motorway system. The seriousness of this threat to the country's future wellbeing can hardly be exaggerated.

We believe that there can be a " glorious revival " for the railway network and for those associated with it ; but such will be the prize for bold and adventurous thought and action, not for a blind clinging to the past.

M. J. DOUGLASS
Railway Conversion League,
Guildford,
January 9, 1961.

ANGRY YOUNG ENGINEER

SIR,—After graduating in England last June with an engineering degree I am spending a post-graduate year in the States.

Unfortunately, I'm acting as an unofficial placement bureau for four of my former fellow students who do not feel that British industry offers sufficient opportunities and remuneration. This may or may not be the true state of affairs but at this early stage we can only go on impressions. Among several interviews last year I felt that only one company really gave the impression that it knew where it was going, what it was looking for and was prepared to pay (more than many others) for it. In contrast some American companies, especially Bell Telephones, have interviewing down to a fine art designed to suggest an efficient company which knows where it is going, where you can start in it and has opportunities for all—with science on top, not on tap.

Some of the good American firms advertise schemes for further engineering education either in a company school or at a local university. The American science undergraduate knows that if he is to get anywhere he will not finish his formal education on graduation, and that his company will help him. Even in college he is used to far more hard work than his British counterpart and is far from the simple ignorant soul he is imagined to be by his more simple Transatlantic cousins in their higher moments of self delusion.

The impression of opportunity is backed by remuneration compatible with the need for engineers. Furthermore, one does not have to come here to earn more. A fellow graduate is earning twice as much with a French company as he could expect from any British company and even in Turkey engineers earn more both in face and real value of money.

Maybe now it is clear even to the most short sighted that we have lost more than our fair share of world markets, stagnated too long, the trade balance is bad and that maybe some of our traditional industries are just a little too primitive. Now is the time to stop frothing pious platitudes about our chronic shortage of engineers and how little they are paid. Let us hope that the law of supply and demand for engineering knowledge (backed by the Institutions and Engineering Press) operates before we breed a generation of Angry Young Engineers so frustrated that even the most patriotic will go to Canada or Australia. We'll lose our markets and be left selling gin, whisky and Harris Tweed to America and giving guided tours to Americans of our historic monuments, including maybe some shipyards and machine tool firms.

ALEX HENNEY
Charlottesville,
Virginia, U.S.A.,
January 10, 1961.

Book Review

A.C. Motor Control and Distribution Gear. By R. T. LYTHALL, M.I.E.E. The Belmos Company, Ltd., Belshill, Lanarkshire. Price 15s.

STUDENTS, apprentices and others who may be seeking basic practical information about control gear and distribution switchgear for low voltage a.c. motors will find many of their wants contained in this handbook. Its origins are to be found in two booklets which the Belmos Company, Ltd., has issued for a number of years for the benefit both of its own staff and users of Belmos switchgear. One of the booklets was the reprint of a chapter on air-break flameproof switchgear from *The J. and P. Switchgear Book*. The other, entitled " Simplified Practice in Certain Classes of Low Voltage Motor Control and Distribution Switchgear," was reproduced from the *Journal of the Association of Mining Electrical and Mechanical Engineers*. Mr. Lythall was the author of both booklets. When, in time, some of the information in these booklets began to become obsolete it was decided, instead of revising them individually, to combine the matter, bring it up-to-date and add new material to make a new handbook. Although the resulting book does not purport to be a complete treatise on the subject it should be very useful to beginners as well as established practitioners. The text is divided into sections covering the following topics : standard methods of starting a.c. motors ; some simple control circuits and sequence interlocking schemes; protective gear ; airbreak industrial equipment ; the problem of short-circuits related to busbars and apparatus on industrial group motor control boards; and airbreak flameproof equipment.

It should be appreciated that the descriptive matter relates to the practice of the company with which the author is associated and is illustrated by that company's products. Within these limitations, however, the book can be recommended as a sound introduction to the subject. In a future edition its value would be enhanced by the addition of an index.

Books Received

The Exploration of Space. Edited by Robert Jastrow. The Macmillan Company, New York. 10, South Audley Street, London, W.1. Price 38s. 6d.

Radioactive Wastes, their Treatment and Disposal. General Editor, John C. Collins. E. and F. N. Spon, Ltd., 22, Henrietta Street, Strand, London, W.C.2. Price 55s.

Repertorium und Ubungsbuch der Technischen Mechanik. By István Szabó. Springer-Verlag, Berlin-Wilmersdorf, Heidelberger Platz 3, W. Germany. Price DM.24.

Reinforced Concrete Chimneys. Second edition. By C. Percy Taylor and Leslie Turner. Concrete Pubications, Ltd., 14, Dartmouth Street, London, SW.1. Price 12s.

Theory and Practice of Arc Welding. Second Edition. By Raymond J. Sacks. D. Van Nostrand Company Ltd., 358, Kensington High Street, London, W.14. Price 45s.

An Elementary Treatise on the Mechanics of Fluids. By W. J. Duncan, A. S. Thom, A. D. Young. Edward Arnold (Publishers), Ltd., 41, Maddox Street, London, W.1. Price 50s.

Basic Synchros and Servomechanisms. Part 1. Developed by Van Valkenburgh, Nooger and Neville, Inc., The Technical Press Ltd., 112, Westbourne Grove, London, W.2. Price 16s.

Britain's Scientific and Technological Manpower. By G. L. Payne. Stanford University Press, Stanford, California. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 45s.

Waste Treatment : Proceedings of the Second Symposium on the Treatment of Waste Waters. Edited by Peter C. G. Isaac. Pergamon Press, Ltd., 4 and 5, Fitzroy Square, London, W.1. Price 84s.

Mineral Processing. By E. J. Pryor. Second Edition (of An Introduction to Mineral Dressing) By E. J. Pryor. Mining Publications, Ltd., 482, Salisbury House, London Wall, London, E.C.2. Price 90s.

Floods

By F. NEWHOUSE, F.C.G.I., B.Sc. (Eng.), M.I.C.E., M.I.W.E.

Unprecedentedly heavy rainfall during the late summer and autumn of last year led to the occurrence of serious floods in several parts of England and Wales. In this article the author discusses the extent to which the heights of floods can be predicted and what can be done to alleviate flooding. He points out that the Government has undertaken to appoint a commission on flood prevention which is to report by midsummer of 1961, *and he outlines the terms of reference and instructions which might appropriately be given to the commission.*

A FLOOD, in the popular meaning, is an irruption of water (O.E.D.). Floods are caused by heavy rainfall somewhere in the catchment of a river near to, or far from, the site of the irruption. For instance, rainfall in Abyssinia causes floods on the Nile, thousands of miles away in Lower Egypt.

Rainfall is a natural phenomenon that cannot be prevented from occurring, though its effects, for good or bad, can be controlled by suitable works designed by civil engineers and farmers. In many parts of the world floods can thus become beneficial, and even necessary, for survival and prosperity, of which fact Egypt is the outstanding and oldest example. The need for protection against flood has been impressed on the British public by many disasters, but only of late years, and in only a few areas, has any beginning been made in collecting the physical data without which no design for a Flood Protection Scheme can be made.

Definitions of " Flood " and " Flood Prevention "

The term " Flood " as used in a technical sense is defined as the irruption of water on to land that is not normally under water, from which it follows that flood prevention means confining the run-off from rain within definite boundaries by means of dams and barrages, drainage channels, river diversions, heightening and reveting river banks, and improving coastal defence works, with such subsidiary works as may be necessary, including weirs, spurs, groins, river walls, &c. (Briefly, one may say floods are like dirt, " matter out of place.")

As rainfall cannot be controlled, the run-off may be excessive and thus cause a " flood," as above defined. Methods of controlling run-off so as to prevent such floods, are therefore called flood " prevention " schemes. The Great Ouse Scheme has, however, been called Flood " Protection " Scheme by Act of Parliament, so that is that.

Efforts are, however, being made in several countries to make clouds drop their rain as and where required, but such efforts still have haphazard results. No attempt has been made, nor can any means be suggested, for dispersing those heavy massive clouds that may cause floods. Till rain cloud dispersal becomes a possibility, flood prevention must remain a matter of reservoirs and dykes.

Hydrography and Meteorology

No proposals for flood control can be studied till the geography, especially the contours, of the relevant areas have been mapped and its rainfall and waterflow measured. The British Isles are well covered by surveys on various scales made by the Geographical Survey, but contour maps to the required vertical intervals are not available everywhere. Hydrography, the science of the flow of rivers, is in its infancy, though meteorology (rainfall) is studied widely and recorded efficiently, the results being published annually in great detail. Contour maps can be made practically once for all, with revisions at long intervals, but to obtain worth-while results in river measurements they must be continued for many years, before reliable mean values can be established. In meteorology, thirty-five-year means are available. One of the earlier water engineers of eminence, Sir Alexander Binnie, laid down in 1892 that thirty years to thirty-five years' measurements were required to enable a reliable design to be made for water supply to a town. The critical value for such works is the minimum flow in the sources (rivers) that furnish the supply, but a much longer period is required to determine the probable size of the maximum flood against which protection can be given. Much research is being done into the relation between rainfall and run-off, but is hampered by the above-mentioned lack of data on river discharges. Moreover, the physical factors which determine the amount of run-off are so many and so complex that it is impossible to formulate a law or a generalisation to serve as a basis for calculating run-off applicable to all catchments. This will be realised from the list (to be given below) of the phenomena that have to be taken into account.

Data Required

Measurements should be available of the total amount, the intensity, the duration, and the extent of all rainfall, necessitating a substantial increase in the present number of rain-gauges. A survey must be made showing the nature of the vegetation that covers each catchment. It should give measurements of the (approximate) area of forest, stating how it is divided among various kinds of tree ; areas of bush and undergrowth, of each kind of crop, of grass, &c. The geological survey must give areas of rock, sand, clay, &c. Other factors to be taken into account are the state of dryness of the soil at the time of rainfall, which depends on the slope of the land, natural and artificial drainage, and on meteorological features such as sunshine and wind. Many of the above features are not capable of quantitative measurement, while some vary greatly over any one catchment, and others greatly with time. Even if the meteorologists are right in affirming that there is a probable maximum rainfall in any given area for a given number of years, it does not follow that the run-off can be determined, for it is not directly proportional to rainfall, as is evident from a consideration of the above-mentioned controlling factors. For example, a thaw combined with a rainstorm over an area covered with snow on soil hardened by frost, and therefore temporarily impermeable, can produce a run-off of over 100 per cent of the rainfall in a given time, while the run-off from a rainfall of the same intensity and duration on a dry sandy soil may be only a small percentage of the precipitation.

However, engineers are not entirely helpless, for there are not a few hydro-electric schemes in the British Isles which have been designed and built without any knowledge of the water available, other than what could be guessed (" deduced " in scientific language) from isohyets. Often there has not been a single rain-gauge within the catchment whose waters are collected to feed the turbines, nor any measurements of streams. Nevertheless, by the exercise of judgment, based on experience, engineers have built hydro-electric schemes which produce the designed units of electric power per annum. (" What's the matter with a bit of luck? ")

While the measurements of rainfall and river are being spread over the catchments to be protected, the contours can be levelled and mapped, and the agricultural and geological data compiled to give the design engineer the information he will require. Twice this century Great Britain has improvised a fine well-trained and very large Army in about two years from a very small beginning. The meteorological and hydrographical data available in Great Britain at present bear the same proportion to what are required for flood prevention and protection, as the Armed Forces of 1914 and 1939 bore to the requirements in 1917 and 1942. Not three years, but at least thirty, will be required to bring the deficiencies in our hydrology up to the required standard. It is no use measuring a river three times a day every day for two years thinking to obtain the knowledge that 2000 discharge measurements judiciously spread over thirty or forty years would give us—Nature simply isn't like that ! The demand to do something now to prevent a recurrence of the 1960 flood damage can be met to some extent in many catchments, for there are obvious revetments, clearances, straightening and enlarging channels, &c., which could be carried out without delay and yet fit into any future comprehensive scheme, while at the same time mitigating, at least, floods similar to those of 1960, pending the final scheme. Any " final scheme " must depend on the size of the Normal Maximum Flood (N.M.F.) for the catchment concerned, from which the " catastrophic flood " for the catchment is determined. The latter term is defined by the Institution of Civil Engineers' Committee on " Floods in relation to Reservoir practice "[1] in an interim report published in February, 1960. The definition states that " the peak rates of acute catastrophic floods may be estimated as " at least " twice those of Normal Maximum Floods." A further quotation from this report states " a general principle is that the worst possible combination of circumstances should be taken into account." The sub-committee of three who prepared this report are acknowledged as outstanding authorities on their subjects ; their recommendations cannot be ignored. " Normal " in the sub-committee's definition means the average of all previous floods, of which " reliable " records exist. The operative words in the above quotations are " at least " and " reliable."

Finance is a major factor in all schemes, but if there is a probability of loss of life, the whole financial aspect will change, for obviously financial cheese-paring cannot be allowed if it may cause death, just as cheese-paring was not allowed in bringing the Armed Forces from 1914 and 1939 strengths up to 1917 and 1942 strengths. Which does not mean that extravagance and waste of money should be tolerated, but stress should be laid on such a point when presenting a scheme for financial sanction.

Afforestation

It is a popular idea that forests, and trees generally, will increase rainfall, but it is difficult to find any reason for such a belief, nor has research yet produced evidence that such a phenomenon occurs. There is here perhaps a confusion between rainfall and run-off, in a Humpty-Dumpty kind of way. The "reasoning" seems to be that as the destruction of forests and vegetation causes erosion and thus increases run-off, so if you grow forests you will get increased precipitation, plus the increased run-off! There is no reason for expecting any benefit to run-off from afforestation, except for "fog-drip," which might be of some importance, though its effect is difficult, if not impossible, to measure. Dr. Rutter[2] has defined "fog-drip" as the fall of water condensed on leaves and branches in regions of frequent fog and low cloud.

Run-Off

The presence of forests, undergrowth and vegetation, such as crops or wild grasses, implies that there is fruitful soil and rainfall. The production of vegetation is a long and intermittent process, due to the fact that while the vegetal cover is still thin, rainfall causes erosion of the valuable soil, when there is a heavy storm. There must be sufficient gentle rain to enable vegetation to grow and thus protect the soil when the heavy eroding storms come. Forests and vegetation reduce run-off by the common natural effects anyone can see for himself. Some of the rain falls on the leaves and gets evaporated, while some of the rain that reaches the ground is absorbed into the roots and plants generally. Both these actions reduce the run-off. Moreover, vegetation generally, including the scrub and undergrowth in forests, retards the flow of water over the ground, so that much of it sinks down to augment the sub-soil storage, while some flows direct into a stream. Sub-soil water, thus well maintained, feeds the streams when there is no rain and therefore no surface run-off. When forests are felled, vegetation harvested or eaten off by cattle, goats or wild animals, the soil is left exposed so that erosion can take place.

Erosion

Erosion is not an important factor in these Isles at present. It is classified in three categories which merge into each other, namely sheet erosion, rill erosion and gulley erosion. Sheet erosion is the slow removal of top soil from sloping land by rainwater flowing over it in a sheet, at times scarcely noticeable. The drain into which the eroding sheet of water falls will, however, begin silting, thus giving a signal which must not be ignored. This form of erosion can be prevented by contour ploughing and terracing. Rill erosion starts from ploughing that is badly sited with regard to landslope: ploughing must be across a slope, not down it. If rill erosion gets out of hand, gulley erosion develops: this carves the land into ravines till it looks as if it were an assembly of huge long ant-heaps springing from some resistant stratum well below the original pre-erosion land level. As arable land increases in area in the British Isles, while grass and woodlands decrease, the danger of erosion increases rapidly, especially on land that has a big slope. Here terracing is necessary, which is an expensive precaution, but better than destruction by gulleying in a wet season like that of 1960. The causes of erosion, its prevention and cure have been the subject of much literature. In this article all that can be said is that it can be prevented, but if it occurs every rain storm will increase the damage. It has occurred, and is occurring, in many parts of the world. It can be reversed only slowly, with constant care and expenditure, where "slowly" means decades or longer, depending on the degree of erosion that has occurred. To see an area that has suffered gulley erosion makes one realise how it is that overcropping has ruined many a civilisation.

Methods of Flood Control

The object of flood prevention is to channel the run-off from heavy storms so that it shall not injure crops or buildings by overflowing. The direct destruction of crops by intense rain falling on them cannot be prevented; hence no known flood protection scheme has such an aim.

Rainfall runs into streams, streams into rivers and rivers to the sea. The fact that many important rivers in the British Isles have estuaries flowing through areas closely cultivated and populated adds further uncertainties to those that the flood prevention engineer has to meet on the tributaries of such rivers. The difficulty is to determine the size of the flood against which protection can be given on reasonable terms. What "reasonable" means in this connection will, it is hoped, emerge from the discussion to follow. When the "reasonable" quantity of run-off is agreed for any area, the problem of flood prevention boils down to canal design in all its details.

The simple straight-forward engineering approach to flood prevention would be to form a reservoir on every stream or brook by a suitable dam or barrage, large enough to give control over the quantity of water that is to enter the main river. The latter must then be enlarged, its banks heightened and all necessary protective works made to keep it between its designed banks.

The mere enunciation of proposals for such measures, if made seriously, for almost any catchment in the British Isles, would raise a howl from the nature lovers (not without cause, it must be admitted) and from the landowners who would have to suffer expropriation of the land to be submerged by the reservoirs, which may be of substantial area. Moreover, a good site for a dam requires good foundations, a narrow place in the valley (to shorten the length of the dam) a fairly impermeable leak-proof sub-soil under the reservoir and above all the capacity in the valley to make a reservoir large enough to reduce the maximum flood to safe proportions. These requirements are seldom available in these Isles, while the cost of building large numbers of small dams would be prohibitive.

Thus, the flood prevention schemes boil down to enlarging the streams and rivers, whose overflow has caused damage in the past. This must affect the untouched charm of many valleys, but careful siting of the works, combined with expert landscape gardening, can ensure that in a very few years the scars disappear, and the works melt into the country behind them.

Barrages have advantages that should not be overlooked but the case against them is strong. Their purpose, if they form even a small fore-bay, is to enable some control to be exercised on the timing of flood water entering the main stream. The help derived in flood control by synchronisation of the streams has been pointed out by Brigadier-General A. K. Sibley, of the New England Corps of Engineers, in a review of "Flood Control in Connecticut,"[3] but it seems feasible in only a few of the catchments in these Isles. American practice finds it is better to build small dams on the small streams, rather than one large dam on the main stream, but in the British Isles, and especially in England, as has already been pointed out, sites for dams, small and large, that would produce reservoirs of adequate size, are difficult to find. Moreover, a large dam alone would give little protection to the catchments of the smaller tributaries. Whatever reservoirs are made, improvements of the rivers by heightening and strengthening the banks, protecting the bed and sides from erosion, cutting diversions through bad bends and so forth, will still be found necessary in all cases. Such works are unavoidable for any flood prevention scheme, but will cause much trouble, especially among those landlords who have been encouraged by Government circulars to build on the flood planes of rivers. We can hope, at least, that the authorities responsible for housing have now realised that rivers do flood their flood-planes, i.e. the berms along each side of a river's channel. It is only a few years ago that a circular was issued to municipalities, complete with sketch, instructing them to build on flood-planes if they were short of land for housing.

Estuaries

On each main river the estuary forms a major difficulty in devising a flood prevention scheme. The main objections are made by shipping and dock interests, who fear that the scheme will cause changes—never mind whether good or bad, but changes—in the shipping channel. This follows, of course, because the water that used to flood the countryside upstream of the harbour will now be prevented from doing so by the flood prevention works, and thus increase to an unknown extent the current through the shipping channel. A whole new world opens to the simple irrigation engineer, where he has to cope not only with sandbanks and variable channels in the estuary, but with the vagaries of ships and docks (and their owners), loading and unloading relative to facilities at low water and high water, &c. As soon as the irrigation engineer comes up against an estuary his lot is not a happy one. What is the maximum flow that will arise, and how long will it last? What will it do to anchorages and shipping channels? Good models will help a great deal to answer these questions, but the 64,000 dollar question "How big will the biggest flood be?" cannot be answered, because no one knows. There is a mass of evidence to support the view that the engineer cannot specify a maximum, without giving some ridiculous figure. The maximum flow even in statistics stretching over hundreds of years may be surpassed by the very next flood season, as will be shown below.

Three questions have to be answered when designing protection for the banks of an estuary, (1) What will be the highest fresh water flow? (2) What will be the highest tide level, allowing for surge? (3) At what period of the tides (neap or spring) will Nos. (1) and (2) coincide?

These three questions can only be answered by assisted guesses, known to scientists and engineers as "extrapolations." As "extrapolation" depends on skill in freehand drawing, it seems to follow that an R.A. should be called in to help in answering the above questions.

Surges

Question (1) has been mentioned briefly above, and more facts will follow. Question (2) needs a few words about "surges." Tide tables are available for very many points along the coasts of Britain that give with great accuracy the predicted tide, i.e. the

tide as calculated from astronomical data. But about one-third or more of all tides are affected by surges in the sea, due to gales from various directions, which sometimes cause tide levels to be below the predicted level, but more often above it. "Residue" is the difference between the actual level recorded during a surge and the predicted level. The maximum residue occurs often, if not always, before the predicted peak, while actual high levels may last longer than predicted high levels. Surges along the east coast of England are due to storms to the north of the North Sea, storms from the north-east being more dangerous than storms from the north-west. Those due to the same storm vary in magnitude along the coast from estuary to estuary, that is to say that the storm that causes a dangerous surge on the Thames may do nothing very significant or dangerous on the Tyne or Great Ouse for instance, or vice versa. The fact that a surge is coming can be predicted, but not its magnitude at any given estuary.

Coincidence of Peak Levels in River and Tide

The anxiety behind this question is obvious. If the peak of a fresh-water flood and the maximum surge occur at a spring tide, they will have a more disastrous effect than their coincidence at neap tide. This is illustrated by the Great Ouse Flood Protection Scheme, which was originally sanctioned to meet the conditions of the 1947 flood, that caused such heavy losses in the Fens. But in that year the above peaks of fresh-water flow and tidal surge coincided at neap tide. If the surge had some a week later, they would have coincided at a maximum (predicted) spring tide. The damage caused would have been substantially greater than it was actually, and the flood protection scheme estimate would have been substantially higher, too. This dangerous coincidence will occur sometime, perhaps not for 100 years, but who is to say, and with what authority, that it will not occur next year? There are less than 100 years' records to help the designer, while many instances are known where records of this length have not included the worst. How much to spend? The problems are obvious, their solution indefinite. The statisticians' theory of extreme values may produce figures of interest to water engineers, as Mr. J. E. Gumbel[4] has said, but the limitations of the statistical method are enormous. The results inspire no confidence in the mind of the engineer responsible for design.

Maximum Possible Flood—A Mirage

It would be as well to scotch, once for all, the idea that the maximum possible run-off on any catchment can be foretold. Many papers and theses have been published on this theme, some purporting, by the use of frequency theories, to determine the possible maximum. Their deductions have too often been disproved in practice. This aspect of flood protection theory is well shown in the report on "Floods in Relation to Reservoir Practice" (mentioned above), which deals with the British Isles only. The facts they quote are disheartening, and are a formidable indictment of all governments, corporations and individual engineers for neglect for years past in collecting data. The Government appears to be specially to blame for suspending the Inland Water Survey in 1952. It was an infant organisation starting from scratch and beginning to organise the essential hydrological surveys when it was disbanded "for economy's sake." In 1954 it was revived under the name "Surface Water Survey." If it is not murdered again, we may begin to have some adequate records in about 1980. After circulation of inquiries to all authorities that ought to know something about the catchments in their charge, 151 replies were received by the I.C.E. committee. They are published and analysed in their report, with dismal conclusions. Only forty-six of the catchments have records longer than twenty years, of which only eighteen are longer than forty years. A few examples will show how inadequate such periods are; they lead to guessing from extrapolations, that is to statistical results of little practical value.

Many unmeasurable variables among the causes of flooding are listed by the I.C.E. committee on page 15 of its report. It is difficult to believe that any mathematical computation could include a measurement of the effect of these natural phenomena on run-off in a quantitative manner such as to give definite figures which an engineer could use in design.

Records, True but Misleading

A few instances of how misleading even long good records can be, are given below.

(*a*) *The Damodar River in India.*—In 1958 Mr. V. N. S. Murthy published in the *Journal of the Institution of Engineers*, India, an analysis of the floods on the Damodar River, at Ranigunj, which, by permission of the Indian Institute of Technology, is given below:

Damodar River

Period dates	Length of record in years	Number of major floods
1857–1887...	31	0
1857–1912...	56	0
1857–1913...	57	1
1888–1918...	31	1
1919–1950...	32	2
1857–1950...	94	3

There were only three major floods in ninety-four years, as shown above, namely: 1913, 650×10^3 cusecs; 1935, 670×10^3 cusecs; 1941, 634×10^3 cusecs.

Mr. Murthy says "Periods of major floods in short records may be greater than the length of the record. Hence, if a short record contains such a flood, extrapolation may lead to error."

The next highest flood to the above three was 422×10^3 cusecs in 1877, while no other was above 400×10^3 cusecs.

Another point that emerges from the above data is the uselessness of "average years" as a guide to floods. The average of all the years but the three high ones would be somewhere between 300 and 400; adding the three high ones would only increase the average by 30 or 40, still giving no hint of the size of the great floods.

(*b*) *The Nile.*—On the Nile, records on the Rodah Island gauge near Cairo go back for nearly 1000 years. They cannot be used to determine the exact heights of floods long ago, because in the old old days taxation varied with the height of the flood, measured in cubits. The cubit was therefore a variable quantity, which might decrease to lower the height of a high flood! But nevertheless the records are good enough to give an idea of the periodicity of high and low floods, nor does it conceal exceptionally low ones, like the flood of 1913, whose total volume was only half any other that occurred during the scientific age, the last ninety years, when exact figures were recorded. It was, however, feasible to deduce from the Rodah gauge records that such a low flood as 1913 had occurred only three times previously, making a total of four times in about 900 years. No mathematical analysis could forecast such a phenomenon for any definite year.

(*c*) *The Great Ouse.*—Nearer home is the Great Ouse Flood Protection Scheme, to which reference was made above. It is now in its last phase of construction. There was a "disastrous" flood in 1937, which induced the Catchment (now the River) Board to engage a firm of consulting engineers to prepare a flood protection scheme. Owing to war delays, the scheme was not presented till 1945. It was filed in 1946 as costing too much. In 1947 another "disastrous" flood occurred, doing much more damage than the 1937 flood. There followed a surge in 1949 which caused still higher levels on the estuary of the Tidal Ouse than the 1947 flood, but because there was no fresh-water flood, no especial damage was done. The designed level of the banks in the estuary was, however, raised to meet 1949 conditions. Then came 1953, still higher than 1937, 1947 or 1949. The estuary had not yet been embanked, but if it had been built to meet 1949 conditions it would have had no freeboard in 1953. So it was heightened to meet 1953 conditions. When something worse than 1953 occurs, the expectation, the hope, is that the present height may be good enough, or, alternatively, damage from breaches, if any, not very extensive. Though precautions cannot be increased and increased indefinitely, the extent of protection to be given cannot be settled by mathematics, but only by the study of previous disasters, the cost of preventing their recurrence and the cost of the damage they have caused, or could cause in the future.

(*d*) *The Thames.*—A further instance of the uselessness of trying to fix absolute maxima is the tale of the Thames Valley and Thames Estuary. The history of "maximum" floods on the Thames is common property, as successive increases in the height of protective walls were promulgated in Acts of Parliament. Leaving out disasters in the seventeenth and eighteenth centuries (mentioning only in parentheses that it has been stated that once in the eighteenth century the Thames caused the floor of Westminster Hall to be 1ft deep in water) a jump can be made to 1879, when an Act of Parliament was followed by a decision to give defence works a height of 5ft above Trinity High Water (T.H.W.). This was amended to 5ft 6in, in 1881, after a bad flood. Then came 1928, when the flood reached 5ft 9in above T.H.W., and caused a death in London. A Commission then decided that 5ft 9in was high enough in London itself, but that the heights of protection above T.H.W. should be increased going upstream, till they reached 7ft, in the reach above Putney Bridge.

More details can be found in the Presidential address of Sir Cyril Kirkpatrick[6], Institution of Civil Engineers, November, 1931. In 1938 the Thames Barrage Association, now defunct, succeeded in forcing the authorities to appoint a technical commission to consider their scheme for a Thames Barrage at Woolwich which would ensure that flood levels would not exceed T.H.W. above the Barrage. It would also give numerous advantages to shipping, including passage to all docks for twenty-four hours a day, and in fact make a "Tideless Thames."[7] Hitler invaded Austria in March, 1938, which led to the Committee of Imperial Defence putting an absolute veto on the construction of any more vulnerable works on the Thames Estuary. The inquiry, fixed for March 28, 1938, was cancelled and none has ever been held, as the post-war Minister of Works curtly refused to consider the scheme. Then came the disaster of 1953, followed by the appointment of a Committee, which in 1954 recommended a "flood barrier" at Purfleet. The Ministry of Housing and Planning called for designs and estimates on this basis, but

little has been heard about them since. The Committee's terms of reference included the limitation that any works they proposed must be cheap. They therefore hedged violently. They pointed out that there could be floods that were much worse than 1953. They gave a table showing a startling increase in the frequency of very high sea levels ; they pointed out that the land level of England is falling and, independently, the sea level is rising. Despite all the foregoing, the Committee said the statistical frequency of the 1953 flood was only one in 200 and there was no need to protect against anything worse. They added, however, that in some areas a lesses degree of protection might suffice, but in others the protection " can " be stronger. Finally, they said, in equivocal terms, that the decision on the scale of defence in any particular must rest with the Treasury.

Two more instances of the nonsense of relying on " maximum " floods are given in the I.C.E. Report of Floods mentioned above.

(*e*) *France.*—The first comes from France. In 1873 a distinguished French engineer studied all floods on the Seine from a great one in 1658 up to 1873, when he pronounced definitely that an exhaustive study made it certain that the recurrence of the 1658 flood " would require thousands of years."

Thirty-seven years later, in 1910, it happened.

(*f*) *Norfolk.*—The other instance is Norwich, where the position of high water of all bad floods is marked. The highest and oldest for three centuries was dated 1614, but the flood mark of 1912 was 15in higher.

Best Means of Flood Prevention

The best means of preventing floods are unfortunately not applicable in the British Isles, as they consist of diverting the water that would cause a flood into lakes or natural depressions, where they can either be discharged into the sea or a river when the flood danger is passed, or the water can be evaporated by natural causes. Such methods have been employed in Iraq, where floods on the Euphrates can be diverted into the Habbaniya depression and further into the Abu Dhibbis depression, while the Tigris can be diverted into the Wadi Tharthar. On the Nile, alternative methods of flood control have been discussed for many years. One proposal is for a reservoir on the Nile large enough to hold the highest flood waters, while another scheme proposes a smaller reservoir in the Sudan and the diversion of flood water into the Wadi Rayan, south of the Fayoum oasis in Upper Egypt. As has been said above, the British Isles do not have waste land suitably placed to afford large spill basins or large reservoirs, though perhaps places might be found where the water of small floods on small streams might be stored till danger was passed.

The Government has undertaken to appoint a commission on flood prevention in the British Isles, which is to report by Midsummer, 1961.

The discussions in this article may be summarised by drafting, with respect, the terms of reference and the instructions that might be given to the commission.

Suggested Terms of Reference for the Commission on Floods 1960-61.

The following initials are used as abbreviations :

R.B.=River Board.
R.B.C.E.=Chief Engineer to R.B.
N.M.F.=Normal Maximum Food.
F.P.=Flood Prevention or Protection.
F.P.S.=Flood Prevention or Protection Scheme.

(1) Do not attempt to fix maximum possible floods.

(2) Flood prevention is the duty of River Boards. Please draft any amendment to the R.B. Act that may be necessary to ensure this.

(3) Appoint one or more small sub-committees to visit each R.B. and consult with its C.E. whether the F.P.S. for its Catchment should be done independently, or whether, from the technical point of view, it should combine with one or more neighbouring Boards.

(4) Each R.B.C.E. is to report whether in his opinion the available records are enough to enable him to calculate a valid figure for the N.M.F. of the river or rivers in his Catchment.

(5) If any R.B.C.E. requires longer and better data to determine the N.M.F. he should give particulars of staff and time required with preliminary estimate of cost of obtaining data.

(6) (*a*) Each R.B.C.E. should be asked to state if possible the provisional N.M.F. for his catchment and to state whether he considers that his F.P.S. should be designed for a catastrophic flood of twice the N.M.F. or for something greater, and if so, how much greater and why.

(*b*) Each C.E. should give a provisional and preliminary estimate of cost for his F.P.S. against a flood of twice the N.M.F. and for any greater flood he proposes.

(*c*) Each C.E. should give an estimate of the staff and time required to make the designs and estimates for each of his above schemes.

(7) Each R.B.C.E. should prepare a statement of all known floods in his area, together with a statement of the damage each did and its cost. This information is very important. The period covered should be as long as possible, but exclude anecdotal evidence unsupported by verifiable facts. The costs should be given both in the values of the period when the floods occurred, and an estimate of the present day values.

(8) Each R.B.C.E. should give an appraisal of the urgency of the F.P.S. in his area and state whether the catchment could be treated in successive sections.

(9) The commission should be ready at all times to discuss questions submitted to them by R.B.C.E's and issue advice or instructions as necessary.

(10) The commission should :

(*a*) Compile a comprehensive report, summarising and embodying such of the reports and requests of the various R.B's as they think necessary.

(*b*) Arrange the schemes in order of importance, giving the preliminary estimate for each.

(*c*) State, as soon as possible, whether any, and which, areas should have early and urgent sanction for a F.P.S., based on technical reasons only.

(11) Finally, the commission should arrange for discussion of the finance of their agreed programme with Treasury officials nominated by the Government.

I. REFERENCES

[1] I.C.E. Publication, " Floods in Relation to Reservoir Practice," February, 1960, by Mr. W. Allard, O.B.E., B.Sc. (Eng.), M.I.C.E., Chairman ; Dr. John Glasspoole, I.S.O., M.Sc. ; P. O. Wolf, B.Sc. (Eng.), A.M.I.C.E.

[2] Rutter, Dr. A. J., Ph.D., A.R.C.S., " Effects of Afforestation on Rainfall and Run-off," *Water and Water Engineering*, March, 1958.

[3] Sibley, Brigadier-General A. K., New England Corps of Engineers, " Flood Control in Connecticut," Seventy-sixth Annual Report of Connecticut Society of Civil Engineers, 1960.

[4] Gumbel, Mr. J. E., " Statistical Theory of Floods and Droughts," *Inst. of Water Engineers*, May, 1958.

[5] Murthy, Mr. V. N. S., " Effect of Occurrence of Major Floods," *Journal Inst. of Engineers (India)*, June and December, 1958.

[6] Kirkpatrick, Sir Cyril, I.C.E., Presidential Address on " The Tidal Thames," 1931.

[7] " The Tideless Thames," 1946, by J. H. O. Bunge, M.I.Mech.E.

II. FURTHER PAPERS

Further papers read with interest and general benefit in support of, or in opposition to, the writer's own opinion.

1. Dawson, Mr. G. E., B.A., A.M.I.C.E., " Discharge from Heavy Rainfall," *I.C.E. Proceedings*, August, 1958.

2. Nash, Mr. J. E., M.E., A.M.I.C.E., " Run-off from Rainfall," *Proceedings I.C.E.*, June, 1958.

3. Barnett, Mr. A. P., " How Intense Rainfall Affects Run-off and Soil Erosion," *Agricultural Engineering*, November, 1958.

4. Lewis, Mr. W. K., B.Sc. (Eng.), M.I.C.E., " Investigation of Rainfall, Run-off and Yield on the Alwen and Brenig Catchments," *Proceedings I.C.E.*, September, 1957, and discussion, March, 1958.

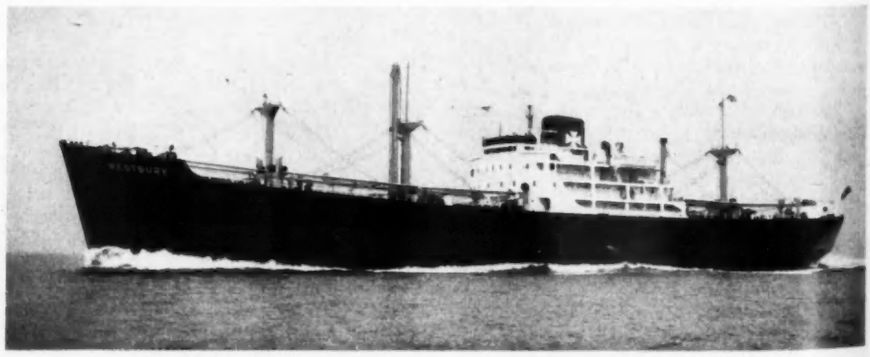
Shipbuilding and Marine Engineering in 1960

No. III—(*Concluded from page 55, January* 13)

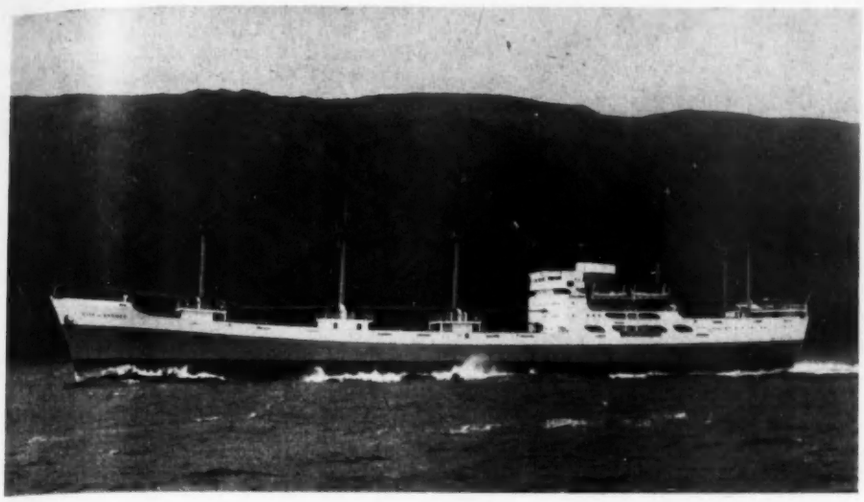
WE conclude our reviews of 1960 with particulars and illustrations of various ships which are indicative of diverse categories of ships delivered by British shipyards.

Cargo-Passenger and Cargo Ships

The open shelter deck cargo ship " Rembrandt " was built and engined by Smith's Dock Company, Ltd., for the Bolton Steam Shipping Company, Ltd., and has a deadweight of 12,900 tons. A loaded service speed of 13 knots is maintained by machinery of 4000 s.h.p., consisting of five G.S. 34 free-piston gasifiers which supply a single-stage, non-reversing turbine driving a controllable pitch propeller built by the Stone Marine Engineering Company, Ltd. The propeller is driven at 110 r.p.m. through a set of double reduction locked train gearing. The



Cargo liner " Westbury " for Alexander Shipping Company, Ltd.



Fast cargo liner " City of Sydney " for Ellerman Lines, Ltd.

ship has a length between perpendiculars of 460ft by 63ft beam by 41ft 9in depth to upper deck and a draught of 27ft 8in, and the cargo from the five holds is handled by four 10-ton and six 5-ton derricks rigged from three bipod masts. Two 200kW diesel-driven generators and two 75kW diesel-driven auxiliary generators supply electrical power. A fuller description of the ship appeared in THE ENGINEER on July 29, 1960.

Early in the year Harland and Wolff, Ltd., handed over to Andrew Weir and Co., Ltd., the " Elmbank " which measures 450ft length between perpendiculars by 62ft 6in breadth by 38ft 6in depth to upper deck and has a gross tonnage of 6300 (open shelter deck) and 8700 (closed shelter deck). The five cargo holds are served by one 25-ton, two 10-ton, twelve 5-ton and two 3-ton derricks operated by fourteen electric winches. Three 175kW diesel-driven generators provide electrical power and propulsion is by a Harland and Wolff two-stroke, single-acting, opposed-piston oil engine having six cylinders of 620mm bore by 1870mm combined stroke.

Our illustration shows the cargo liner " Westbury " which was built by the Burntisland Shipbuilding Company, Ltd., for the South American trade of the Alexander Shipping Company, Ltd. A Hawthorn-Doxford opposed-piston oil engine of 5500 b.h.p. at 115 r.p.m., fitted to burn heavy oil, is the propelling unit and the ship carries a deadweight of 11,900 tons on the following dimensions : length between perpendiculars 430ft, beam 61ft 9in, depth to upper deck 38ft 3in and load draught 28ft 10in. Cargo from the five holds and 'tween decks is handled by one 50-ton, six 12½-ton and eight 5-ton derricks. Electricity for all services is supplied by three 200kW diesel-driven generators.

Built to the order of Ellerman Lines, Ltd., by Barclay, Curle and Company, Ltd., the " City of Sydney," illustrated herewith, measures 511ft by 67ft by 42ft and has a gross tonnage of 10,550, a deadweight of 11,570 tons and a service speed of 17 knots. This closed shelter deck cargo liner has five holds complete with lower and upper 'tween decks, a complement of one 20-ton, eight 10-ton and ten 5-ton derricks, and electric deck auxiliaries. Propulsion is by a Barclay, Curle-Sulzer single-acting, two-stroke oil engine, arranged to burn heavy oil fuel, having nine cylinders of 760mm bore by 1550mm stroke and being fitted with three turbo-blowers. Steam for various purposes is raised in one vertical exhaust gas boiler and two vertical oil-fired boilers, while there are four 320kW diesel-driven generators.

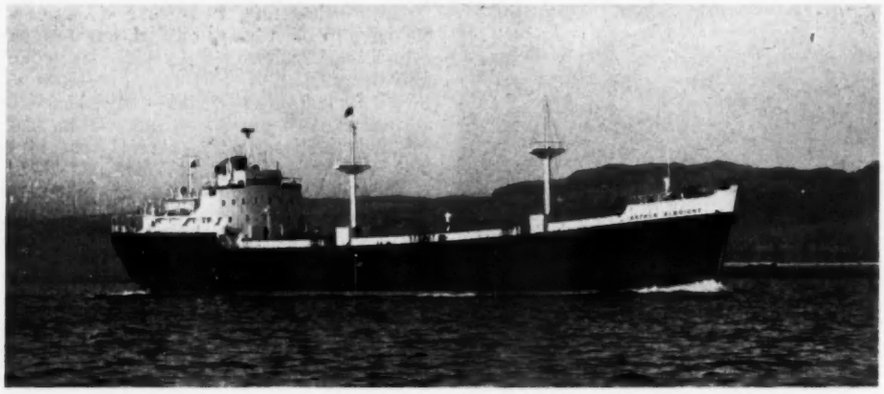
The Caledon Shipbuilding and Engineering Company, Ltd., built the " Maron " for the Far East trade of Alfred Holt and Co., and the ship, which has a deadweight of 9800 tons and a sea speed of 15 knots, has the following dimensions : length overall 495ft, breadth moulded 65ft, and depth moulded to upper deck 36ft. There is accommodation for twelve passengers. Two 15-ton, six 10-ton and eighteen 5-ton derricks serve the six holds and 'tween decks, while one 7-ton derrick serves the engine-room, and operation is by twenty-four electric winches. Propulsion is by an exhaust-pressure-charged, single-acting, opposed-piston oil engine supplied by John G. Kincaid and Co., Ltd., and rated at 8500 b.h.p. at 115 r.p.m. There is a Thompson La Mont forced circulation boiler and also La Mont waste heat units, and three 330kW diesel-driven generators.

Clan Line Steamers, Ltd., took delivery of the cargo liner " Clan Macilwraith " towards the end of the year and the ship, which was built by the Greenock Dockyard Company, Ltd., carries a deadweight of 9970 tons on 26ft 4¼in mean draught. The principal particulars of the ship, which we illustrate, are 455ft length between perpendiculars, 61ft 6in beam, 38ft 7½in depth and a gross tonnage of 7350. Cargo is carried in five holds and handled by one 80-ton, one 40-ton, four 15-ton, two 10-ton, two 7-ton and ten 5-ton derricks powered by sixteen electric winches. Three 185kW diesel-driven generators provide electric power and the service speed of 15 knots is maintained by a five-cylinder Wallsend-Doxford diaphragm pattern opposed piston oil engine developing 5000 b.h.p. at 110 r.p.m.

The Neptune Works of Swan, Hunter and Wigham Richardson, Ltd., completed for the Palm Line, Ltd., the " Lobito Palm " which we illustrate and which attained a speed of 17¾ knots on trial. Propulsion is by a Swan Hunter-Doxford oil engine, built at the Neptune Engine Works, having six cylinders of 700mm bore by 2320mm combined stroke and designed to develop 7500 b.h.p. at 118 r.p.m. The engine is of diaphragm design and is arranged to burn

" Lobito Palm " for the Palm Line, Ltd.

Cargo ship " Clan Macilwraith " for Clan Line Steamers, Ltd.



Bulk phosphate carrier "Arthur Albright" for A. and W. (Overseas Developments), Ltd.

boiler fuel. The ship is rigged with three bipod masts and one 50-ton, four 15-ton, two 10-ton and ten 5-ton derricks, operated by sixteen electric winches, to serve five cargo holds. Power for deck and auxiliary machinery is provided by three 250kW Crossley diesel-driven generators. A deadweight of 8500 tons is carried on 25ft draught and the following dimensions: length between perpendiculars 440ft, breadth 63ft and 37ft depth moulded to shelter deck.

The "City of St. Albans" was delivered to the Ellerman and Bucknall Steamship Company, Ltd., by William Denny and Brothers, Ltd., and the ship, which measures 433ft length overall by 59ft beam by 36ft 9in deep to shelter deck, has a displacement of 12,400 tons and a deadweight of 8350 tons on a draught of 26ft 1½in. Cargo is carried in four holds and the cargo gear consists of four 10-ton and six 7-ton derricks powered by ten electric winches. Electric power for deck and auxiliary machinery is supplied by three 180kW diesel-driven generators. An eight-cylinder Denny-Sulzer, two-stroke, single-acting oil engine developing 5040 b.h.p. at 120·7 r.p.m. gives the ship a service speed of 14 knots.

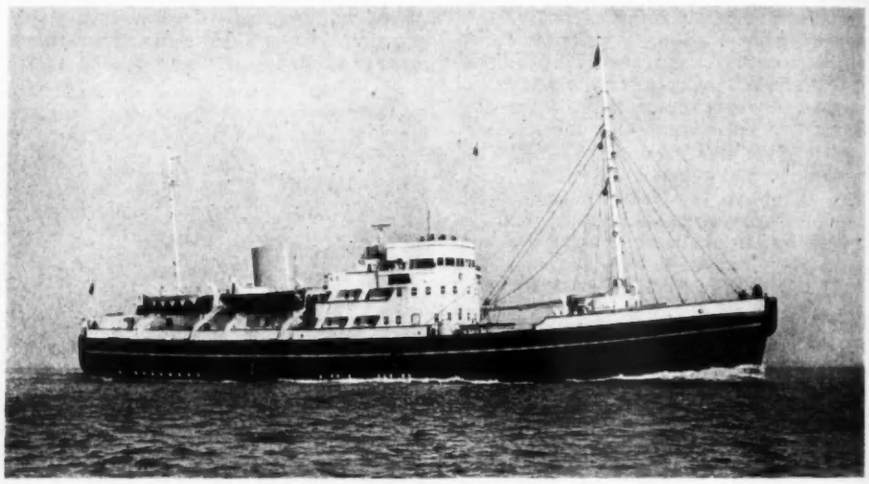
Hall, Russell and Co., Ltd., completed for the Donaldson Line, Ltd., the "Colina" which will trade to the St. Lawrence Seaway and is an open shelter deck vessel having a length overall of 294ft 6in by 44ft 6in beam by 26ft depth to shelter deck and a deadweight of 2500 tons on 17ft 10in draught. There are three holds, two 7-ton and six 5-ton derricks, and propulsion is by a five-cylinder, two-cycle, Mark "T" British Polar oil engine of 2000 b.h.p placed aft. Two 125kW diesel-driven generators provide electrical power.

Bulk Carriers and Oil Tankers

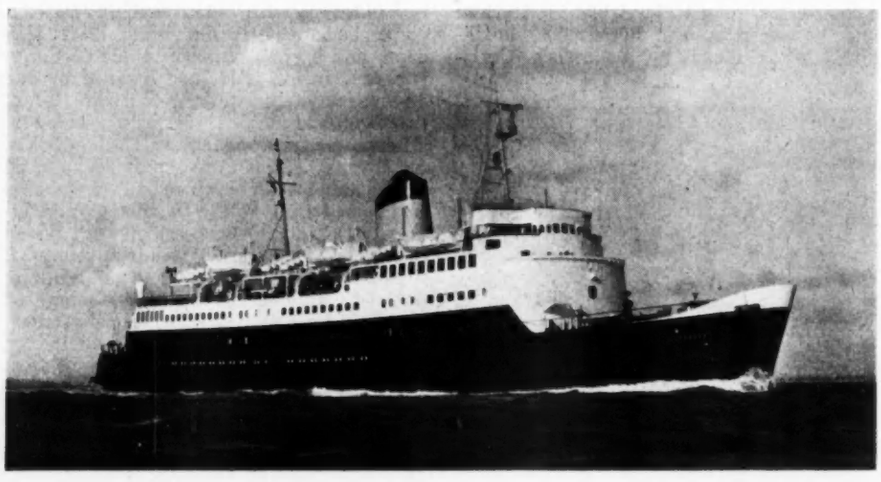
The bulk phosphate carrier the "Arthur Albright" which we illustrate, was constructed by The Burntisland Shipbuilding Company, Ltd., for A. and W. (Overseas Developments), Ltd. The ship has machinery arranged aft and the main particulars are: length between perpendiculars 390ft, beam 56ft 9in, depth 36ft and deadweight 10,275 tons on 28ft 1in draught. There are four holds, with deep tanks arranged between No. 1 and No. 2 holds and between No. 2 and No. 3 holds, and a Hawthorn-Doxford oil engine of 3300 b.h.p. provides the propelling power. Another bulk carrier was the "Athel Princess" built for the Athel Line by the Caledon Shipbuilding and Engineering Company, Ltd., and designed to carry 11,700 tons deadweight on 27ft 1in draught at a service speed of 13½ knots. The untrimmed sugar capacity is 500,000 cubic feet and the grain capacity 626,000 cubic feet and the cargo is carried in five centre line holds fitted with MacGregor steel hatch covers. There are three masts and one 25-ton and ten 10-ton derricks operated by Clarke Chapman steam-driven winches. Propelling machinery consists of a five-cylinder Hawthorn-Doxford oil engine, of 5500 b.h.p. at 112 r.p.m., and the electrical plant consists of one 75kW steam-driven and two 240kW diesel-driven generators supplied by W. H. Allen, Sons and Co. Ltd.

The Furness Shipbuilding Company, Ltd., handed over to Shell Bermuda (Overseas), Ltd., the 31,725 tons deadweight oil tanker "San Conrado" which measures 630ft length between perpendiculars by 87ft beam by 45ft 6in depth, and has a summer draught of 34ft 2½in. There are ten treble tanks and one main cargo oil pump room fitted with four 900 tons per hour centrifugal turbine-driven pumps and four 150 tons per hour vertical stripping pumps. The main suction and the discharge and deck filling lines are of 13¼in bore. Two 600kW turbo-driven alternators generate power at 450V. and 60 c/s, and propulsion is by a set of Metropolitan-Vickers double-reduction, geared turbines developing 12,500 s.h.p. at 105 r.p.m. and using steam supplied at 600 lb per square inch and 850 deg. Fah. by two Foster Wheeler "D" pattern boilers. Shell Tankers, Ltd., took delivery from Smith's Dock Company, Ltd., of the "Amoria" which has a length between perpendiculars of 530ft by 69ft 3in beam by 39ft depth and a deadweight of 18,062 tons on 29ft 10in draught. Oil is carried in thirty-three tanks and handled by four 400 tons per hour, two-stage, turbine-driven centrifugal pumps and two 200 tons per hour vertical duplex stripping pumps. Electric power is supplied at 440V, 60 c/s by one 100kW steam-driven and two 400kW diesel-driven alternators, and a Hawthorn-Doxford oil engine having six cylinders of 650mm bore and equipped with two turbo-chargers develops 7500 b.h.p. at 112 r.p.m. to give a speed of 14½ knots.

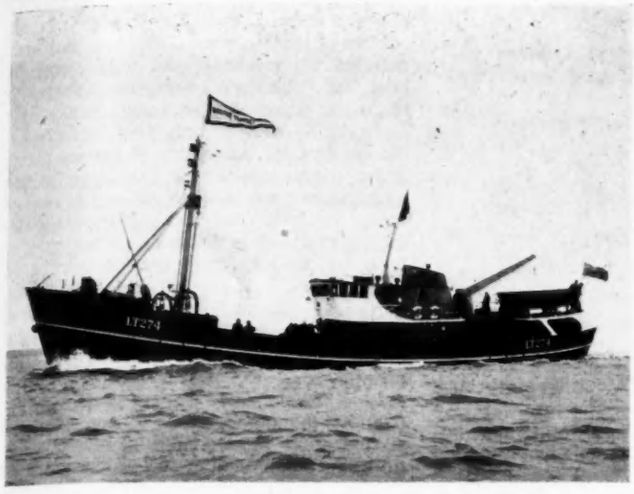
Among the small tankers completed was the "Charmo" which was built to supply the Poplar Depot of Charrington, Gardner, Locket (London), Ltd., with fuel oil from Coryton refinery, and was described in THE ENGINEER on April 8, 1960. This river tanker measures



Lighthouse tender "Siren" for Trinity House



S.S. "Caesarea"



Near water trawler "Boston Provost"

Light vessel "Skua" for the Commissioners of Irish Lights

163ft 3in by 32ft 6in by 10ft 6in and carries 500 tons of fuel on 8ft 6in draught. The air draught is limited to 14ft to allow for operation above bridges. There are six fuel tanks fitted with heating coils and two 150 tons per hour Mirrlees cargo oil pumps. Propulsion is by two Mark E.V.S.M. 4 Lister Blackstone oil engines, each of 256 b.h.p. at 600 r.p.m., which drive a single propeller through Modern Wheel Drive reverse reduction gearing.

Short Sea and Smaller Craft

The "Caesarea," of which we reproduce a photograph and which was described in our issue of December 9, 1960, was built by J. Samuel White and Co., Ltd., for the Weymouth-Channel Islands Service. The ship has one class accommodation for 1400 passengers and has the following dimensions : length overall 322ft, breadth 51ft, depth to main deck 18ft 9in, draught 13ft 6in and gross tonnage 4174. A bow rudder and Denny-Brown stabilisers are fitted and this ship is propelled at 20 knots by two sets of single casing double-reduction geared turbines having a total output of 8500 s.h.p. at 275 propeller r.p.m. Two Foster Wheeler "D" pattern watertube boilers supply steam at 350 lb per square inch and 650 deg. Fah. Another ship completed by J. Samuel White and Co., Ltd., was the lighthouse tender "Siren" for the Corporation of Trinity House, which was described in The Engineer dated March 18, 1960. The ship, seen in our illustration, has a length overall of 221ft by 37ft 6in beam by 23ft 6in depth to upper deck, and a draught of 13ft. Clarke Chapman and Co., Ltd., supplied the special service electrical deck machinery and the necessary power is supplied by one of the main generators forming part of the propulsion machinery. This was provided by the English Electric Company, Ltd., and consists of four generators, each rated at 292kW and driven by a six-cylinder C.S.R.K.M. diesel engine, which supply two 460V, d.c., 1270A, propulsion motors rated at 725 s.h.p. at 228 r.p.m.

Trawlers completed during the year included the "Westella" built by Cook, Welton and Gemmell, Ltd., for J. Marr and Sons, Ltd. The ship measures 185ft by 33ft 6in by 16ft 9in and has a fish room capacity of 18,170 cubic feet. A 300 h.p. trawl winch having two barrels, each with a capacity for 1500 fathoms of 3½in warp, is fitted and the main propulsion unit is a Mirrlees "Monarch" class A.L.S.D.M. turbo-charged, six-cylinder, four-stroke, diesel engine rated to develop 1800 s.h.p. at 225 r.p.m. A smaller near water trawler, the "Boston Provost," illustrated herewith, was completed by Richard Ironworks, Ltd., for Boston Deep Sea Fisheries, Ltd., and has a length overall of 116ft 3in by 23ft beam by 11ft depth and a fish room of 5040 cubic feet capacity. The trawl winch has two barrels each able to hold 550 fathoms of 2⅝in warp and is belt driven from the main engine which is a six-cylinder National "Sovereign" turbo-charged diesel engine rated at 515 s.h.p. at 300 r.p.m. Both trawlers were described in our issue of May 20, 1960.

Among the tugs completed was the "Meeching" built by P. K. Harris and Sons, Ltd., for harbour duties at Newhaven and the main dimensions are length overall 9ft 6in, breadth 12ft, depth 12ft and gross tonnage 170. Equipment includes two 220 tons per hour salvage pumps which operate in parallel for salvage duties and in series for fire fighting. Propulsion is by two Lister-Blackstone diesel engines driving through Modern Wheel Drive 3 to 1 reverse reduction gearing, and rated at 660 b.h.p. at 750 r.p.m. The tug has a running free speed of 12 knots and exerts a bollard pull of 14 tons with each engine developing 500 b.h.p.

Our illustration shows the lightship "Skua" constructed by Philip and Son, Ltd., for the Commissioners of Irish Lights. The ship measures 136ft 5in by 25ft by 15ft, and when on station is moored by 1¾in "Tayco" stud link cable attached to a 4-ton stockless anchor. The lantern, placed at 40ft above sea level, has a beam visible for 10 miles. There are two 9kW and two 4½kW diesel-driven generators and two diesel-driven compressors for supplying air to the receivers and the fog signal diaphone.

A firefloat of special design to combat oil fire hazards was built by R. S. Hayes (Pembroke Dock), Ltd., for service in Swansea docks. The "B.P. Firemaster," seen in our illustration, is of catamaran design and the hull consists of two pontoons joined at deck level ; mounted on the deck is an open pyramid formed by four steel tubes which carry two platforms upon which are monitors. Two Merryweather turbine pumps powered by 6.Q.A. Dorman diesel engines deliver 3100 gallons of water per minute at 100 lb per square inch. Propulsion is by two "Harbourmaster" outboard power units, each driven by a Dorman K.U.D. six-cylinder diesel engine of 140 b.h.p. A fuller description of the firefloat appeared in The Engineer dated February 26, 1960.

Catamaran firefloat "B.P. Firemaster" for Swansea Docks

Rocket Propulsion

Early this month the Royal Aeronautical Society, the British Interplanetary Society, and the College of Aeronautics convened at Cranfield a symposium on Rocket Propulsion. Since the construction of rockets using other than conservative propellants is very little practised in this country, we abstract here three papers dealing with the engineering of the more ambitious, though far from "exotic," designs discussed. Where actual experience is described it is based on test work rather than on flight experience, i.e. excluding the problems posed by fluctuating or zero applied acceleration, an evacuated environment, and so on.

PROBLEMS WITH LIQUID OXYGEN IN LARGE ROCKET ENGINES

By I. E. SMITH*

IT is proposed to follow the course of a rocket engine test from the initial filling of the liquid oxygen tanks to the final analysis of the test data. The general layout of such an engine is by now fairly well known. (A diagram of an engine of "Rocketdyne" configuration was shown, and confirmed the description of the injector head given in THE ENGINEER, page 430, Sept. 9, 1960.)

Tank Filling and Pressurisation.—Liquid oxygen is transported at its normal boiling temperature of 90 deg. K, and in this state it is fed into the main tank either on the test stand or in the vehicle. This can be done either by addition of heat to the supply tank, allowing the vapour pressure to transfer the liquid, or it may be carried out by means of a pump drawing liquid directly from the base of the tank.

Once the main tank has been filled further boiling is suppressed by slight pressurisation, and although the liquid still tends to warm up, the surface to volume ratio is usually such that this only amounts to a few tenths of a degree per minute. the liquid which is contained in the line connecting the propellant tank to the engine warms up very much more rapidly since at this point the surface to volume ratio is much higher than in the tank itself. The liquid soon reaches its boiling point, and, in the absence of particles containing absorbed gas, undergoes superheating. When boiling finally takes place the bubbles expand very rapidly indeed, extracting heat from the surrounding liquid, until the system is once more in thermal equilibrium. Now for a superheat of only 1 deg. Cent. one volume of liquid oxygen on boiling will produce twice its own volume of vapour at pressures close to atmospheric, and the resultant pressure surge as the gas escapes into the tank and the liquid falls back on itself has been known to cause serious damage to the engine structure. The remedy for such "geysering" is to provide a continuous circulation of cold liquid oxygen in these lines, either from the tank itself or from a separate source of sub-cooled liquid oxygen. An alternative would be to introduce a small stream of gas to act as a source of nuclei on which bubbles could form and allow gentle boiling to take place, although the author has no first-hand knowledge of this method in practice.

When the preparations for firing are complete the liquid oxygen tank is finally pressurised so that there is no possibility of boiling occurring during the test ; a typical value for this pressure is two or three atmospheres absolute.

Engine Precooling.—When the main valves are opened and liquid oxygen enters the relatively hot engine, vigorous boiling ensues until the metal surfaces have cooled to liquid oxygen temperatures. An attempt to start the engine without precooling would lead to violent and unpredictable transients, but fortunately as far as the main passages are concerned, precooling may be achieved simply by allowing liquid oxygen to flow under tank head for a short while before starting.

It is in the smaller lines, such as the gas generator feed system, where the greatest difficulties are encountered and since this system controls the behaviour of the entire engine especial care has to be taken to ensure reproducible starting conditions. Precooling of the lines up to the last point of control, the gas generator valve, may be achieved by providing a bleed to some point of low pressure in order to allow a small flow to pass, although care has to be taken in selecting the return point, in order not to bleed off a significant proportion of the oxygen supply under steady running conditions. In the "Rocketdyne" engine, in which the oxygen is supplied to the gas generator by a constant pressure regulator, a certain tolerance may be allowable, but for a control system of the constant resistance type a bleed of uncertain magnitude may be most undesirable and introduce more problems than it eliminates. In such cases the designer has no option but to close off the bleed lines with a solenoid valve once they have served their purpose, in spite of the additional complication and unreliability that this entails. To be strictly fair, it must be mentioned that problems of this type apply to unprimed lines in general, although the difficulties are very greatly increased when dealing with a propellant which can, so to speak, generate its own gas pocket.

Because it is not only the surfaces in direct contact with the liquid oxygen which are cooled during this phase, but also many others such as valve spindles, control cylinders, shaft bearings and so on, stringent precautions have to be taken to avoid the presence of condensible gases and vapours which would cause seizure. In this respect it is fortunate that nitrogen has a lower boiling point than liquid oxygen and may safely be used for purging. However, the presence of water vapour must be avoided at all costs if the freezing of controls is to be prevented. In order to err on the safe side heaters are generally fitted in locations where freezing is liable to occur, and a careful check has to be made to ensure they are in operation before a test takes place.

Starting.—For obvious reasons the payload is generally placed at the end of the vehicle remote from the engine, and during the final stages of flight practically the entire thrust has to be transmitted through the propellant tanks. As a result the pressure inside them is dictated more by structural considerations than by the requirements of the engine designer.

In the case of a non-cryogenic propellant the pressure at the pump inlet when the engine is started is to all intents the pressure at the bottom of the tank less the head required to accelerate the fluid along the inlet line. Designers frequently choose to place the liquid oxygen tank ahead of the fuel tank in order to minimise the change in the position of the centre of gravity during flight, which means that the liquid oxygen inlet line becomes at least as long as the fuel tank. Since the acceleration of the propellant during the start is normally of the order of several *g*, the acceleration loss outweighs the gain in static head due to the long inlet line.

As a result, an initial total pressure of say 60 lb per square inch absolute at the bottom of the liquid oxygen tank may easily dwindle to a nett positive suction head of only a few lb per square inch absolute (*sic*) at the pump inlet. If the engine is started under these conditions severe cavitation can result in a reduction in the work capacity of the pump and allow the turbine to overspeed.

The answer may be provided in the design stage of the vehicle by employing as large an inlet line as practicable in order to minimise the acceleration loss. Methods of ensuring that the liquid oxygen which enters the pump during the starting phase is as cold as possible are usually worthwhile, and in certain circumstances it has been found profitable to inject liquid oxygen which has been cooled to the temperature of liquid nitrogen immediately before starting, since a gain of 12 lb per square inch in suction head is possible in this way. From the engine side the problem may be approached by reducing the pump acceleration, which will allow a reasonable suction head to be maintained. There is, however, a limit to which this may be carried since it is unwise to permit the engine to remain for an extended period at a low thrust level on account of combustion instabilities which may occur.

The severity of cavitation effects is influenced not only by the mechanical design of the pump and the conditions under which it is being operated, but also by the specific and latent heats and the liquid/vapour density ratio of the liquid being pumped. A high latent heat is favourable from the point of view of cavitation, in that the production of a small mass of vapour results in a considerable cooling of the remaining liquid. Likewise a low ratio of the liquid/vapour densities tends to be beneficial from this point of view. It is on account of the latter that liquid oxygen provides a better cavitation performance than many other propellants, although the behaviour of liquids subjected to pressures below their vapour pressure under rapidly changing conditions is far from well understood.

Cut-off.—The problems that arise on stopping an engine are in many respects similar to those which were experienced on starting. Just as it was found necessary to bleed dead ends and enclosed spaces in order to achieve proper priming, it is equally important to allow the vapour generated from trapped liquid oxygen to escape. It frequently happens that the same bleed lines or points serve also to vent off the residual liquid oxygen. The main source of trouble at cut-off comes from the liquid oxygen which is trapped between the propellant valves and the injectors, for as the combustion chamber pressure falls below the saturation vapour pressure of the liquid this immediately evaporates. In the case of the gas generator the resultant high mixture ratio can cause damage to turbine blades or guide vanes, and in the main chamber it results in an unpredictable increase in the total impulse. To overcome these problems arrangements may be

* Chief Performance Engineer (Rockets), Rolls-Royce, Ltd.

made for the liquid oxygen flow to be shut off before the flow of fuel, and the injector cavities to be purged with an inert gas. However, both measures result in a still further increase in the complexity of the engine and its control system.

Test analysis.—Having successfully completed a test or flight the next step is to examine the instrumentation records to assess the engine performance. In general the steady state performance evaluation is in theory relatively uncomplicated, involving a measurement of the propellant mass flow rates, and the magnitude and direction of the thrust. The transient behaviour of the engine during starting and stopping, however, is much less straight forward. The importance of the transient behaviour, however, cannot be over-emphasised, since the rate at which the thrust builds up and dies away affects the magnitude of the dynamic stresses in the vehicle to which the engine is attached. Furthermore, from the point of view of the engine itself an off-mixture ratio condition, though persisting for only a short duration of time, can have a dramatic effect on the turbine or thrust chamber life.

By far the most revealing measurement in a rocket engine is that of pressure, either absolute or relative to some other part of the system, and it is in examining the records of pressures in liquid oxygen lines that one receives a rude shock. For example, a glance may indicate that a pressure surge occurred at the pump inlet several times that of the steady running value, and certainly in excess of that which the light weight inlet lines were stressed to withstand. Similarly, a calculation of the mixture ratio from the difference between the oxygen injection pressure and the chamber pressure suggests impossibly high values were present during the start. In contrast the liquid oxygen pressures appear strikingly steady and noise free once steady state operation has been achieved, and at cut-off the transducers record a consistent decrease in pressure with none of the alarming symptoms observed during the start.

The reason for this anomalous behaviour turns out to lie in the way the pressure transducers have been connected into the system. Since the output of all pressure transducers is to some extent dependent upon their temperature, and many are quite unsuitable for use at liquid oxygen temperatures, it is common practice to interpose a length of connecting line between the point in the system at which the pressure tapping is made and the instrument itself. In this manner, the thermal mass of the line ensures that the sensitive pressure element is always insulated from the effects of low temperature by a column of gas, as is illustrated in Fig. 1.

During the start of an engine the increase in pressure forces the liquid to flow along the transducer line compressing the gas ahead of it. This process continues until the pressure in the transducer is equal to the pressure in the main system. By this time the column of liquid has acquired considerable momentum, which results in a still further increase in pressure within the transducer until this momentum is destroyed. The process then reverses itself, and the final pressure record takes the form of a damped oscillation bearing little or no resemblance to the original pressure change.

As the test proceeds the liquid oxygen within the line gradually evaporates, with the result that at cut-off, when the pressures fall, a more faithful record is obtained as the low density gas escapes from the tapping line.

Unfortunately, this inherent ambiguity in the records can be overcome only by employing the rather costly flush-mounting type of transducer which contains a heated sensing element, and as a result an accurate diagnosis of starting transients is a difficult task. Not infrequently the evidence of an abnormal oxygen flow has to be obtained less directly either from its effect on other parameters, or, in the worst cases, components.

The two principal criteria by which a rocket engine is judged are its thrust and specific impulse, the latter involving a measurement of propellant mass flow rates. The increasing mass ratios of modern vehicles have resulted in the need to estimate these mass flow rates to a very much higher order of accuracy than was considered necessary only a short while ago. It is by no means uncommon for an error in the measurement of specific impulse to result in an error two or three times as great in the final velocity, as a result of which accuracies in flow and thrust measurement of significantly better than one per cent are called for.

Accurate liquid oxygen mass flow measurements are difficult mainly on account of the unusual physical properties of the fluid, and in this respect it is unfortunate that the oxidiser flow is more often than not several times as great as that of the fuel.

The most useful instrument for this purpose is the turbine type of flowmeter, which is capable of a repeatability of at least 0·1 per cent. However, when such a flowmeter, which may have been calibrated with water, is used with liquid oxygen certain changes take place to invalidate its calibration.

Firstly, a bodily shrinkage takes place owing to the cooling of the flowmeter to the liquid oxygen temperature, although this can be allowed for without much difficulty.

More serious is the fact that liquid oxygen has a dynamic viscosity only one tenth that of water with a result that proportionately greater boundary layer flow occurs. Although

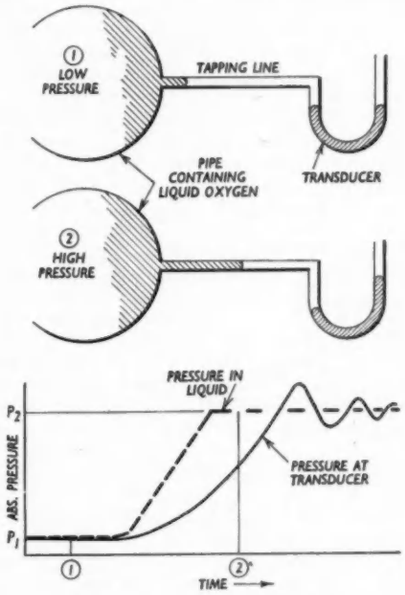


Fig. 1—Instrument response lag

the magnitude of the correction for this effect is known to vary inversely with the dimensions of the flowmeter, it is rendered virtually impossible to apply on account of the unstable flow conditions across the flowmeter.

The only feasible solution turns out to be a direct calibration in liquid oxygen with a storage tank fitted with level sensors. The gauges have themselves to be calibrated by a water weighing method, after which the liquid oxygen volume must be corrected to allow for the tank shrinkage owing to cooling, and the expansion of the liquid due to heat transfer. With good care a *volumetric* calibration may be obtained having an accuracy of the order of $\frac{1}{4}$ per cent.

The remaining step is to translate this volumetric flow into a mass flow rate via the liquid density which can be deduced from its temperature. The precision with which this is required may be judged from the fact that a 1 deg. Cent. temperature change results in a density variation of $\frac{1}{2}$ per cent, and since tests may have a duration of only ten seconds or even less a high premium is placed on the response rate of the instrument. This immediately rules out the vapour pressure thermometer which is highly sensitive to temperature, and one must fall back on either an accurate system of thermocouples or the resistance thermometer. The former require an accurate standard of temperature close to the temperature which is being measured, and although boiling oxygen itself might appear an excellent choice, it suffers from a tendency to superheat before boiling which render it unsuitable under engine test conditions. Fortunately fast responding resistance elements are now available which, with frequent calibration, are capable of an accuracy of about $\frac{1}{2}$ deg. Cent. at liquid oxygen temperatures.

The final result is an accuracy of measurement in the mass flow rate approaching $\frac{1}{2}$ per cent. Although this may not appear unduly high in comparison to laboratory standards, it does reflect considerable credit on the instrument manufacturers.

PACKAGED LIQUID PROPELLANT ROCKET ENGINES

By K. G. PAGE†

The basic concept of the packaged liquid propellant rocket engine is the manufacture of the unit as a single round, in which the propellants are filled and sealed at the factory. It may then be transported or stored in this condition until required for use. After leaving the factory the liquid propellants are neither seen nor do they have to be handled independently of the engine.

The successful packaging of a liquid propellant system depends to a large extent upon the type of application and the demands to be made from the propulsion unit. By far the most attractive unit can be obtained when the requirements are for a continuous single level of thrust, or for simply programmed thrusts similar to those that can be arranged with solid propellant engines. Nevertheless independent thrust control can be included, to an extent which is dependent upon the type of engine considered, and usually at little extra cost in complication.

Engines Using Solid Propellant Pressurisation.—The propellants are hermetically sealed in their respective tanks and are isolated from the pressurising charge and the thrust chamber by rupture devices. Since adequate pressure is readily available both the gas side and the liquid side rupture devices can be designed to operate positively and reliably. The selection of a hypergolic liquid propellant combination eliminates the requirement for an ignition device. The simplicity of the system is immediately apparent and reference to Fig. 2 will show how this basic principle can be engineered into actual engines. This figure shows an engine which is in production for the Martin " Bullpup " and typical of units designed to give a fixed level of thrust for a few seconds. It will be noted that the

† The de Havilland Engine Company, Ltd., Rocket Division.

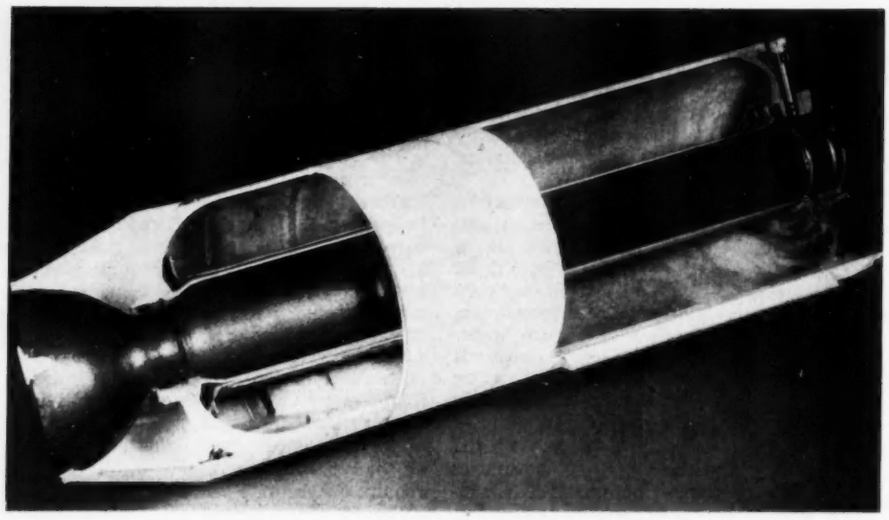


Fig. 2—"Guardian II" made by the Reaction Motors Division of the Thiokol Chemical Corp.

tandem tank arrangement, with both the pressurising charge and the thrust chamber recessed into the tanks, provides a clean and easily handleable package. The engines are capable of long storage times over a wide range of temperature and at all times are ready for immediate use.

Since the pressurising charge is a relatively small but important component, it can be selected primarily for good storage and stable burning characteristics, thus avoiding most of the problems associated with high performance solid propellant charges. For maximum simplicity it is desirable to pressurise directly on the liquid surface, in which case the possibility of gas-liquid reaction must be fully investigated. Ideally the solid charge should have neutral combustion products ; however, the commonly available medium energy propellants most suitable for this purpose invariably give fuel rich combustion products. The existence of a gas-liquid reaction is quite acceptable provided it is safe and consistent so that it can be allowed for in the design of the engine. The satisfactory solution to a problem of an unpredictable or inconsistent gas-liquid reaction will depend largely upon the selection or development of a more suitable propellant pressurising charge. An artificial barrier such as a flexible bag or diaphragm between the pressurising gas and at least one of the propellants (most probably the oxidant) may of course be used, but this solution is also likely to impair the simplicity and perhaps the storage life of the engine.

It is interesting to note that although the pressurising charge will have some variation of burning rate with temperature, the effects of these variations are to a large extent offset by the liquid propellant flow characteristics. In the first place the liquid flow rate varies only as the square root of the pressure drop across the injectors, and secondly the higher liquid bulk temperature gives rise to a lower density which partially compensates for the higher volume flow. These effects combine to result in a unit which has a thrust variation with temperature which is much less than the corresponding burning rate variation of the solid charge. Also, since the pressurising charge may in any case be selected for desirable characteristics in this respect, the resultant engine can have a thrust level which is relatively insensitive to a wide range of initial firing temperatures. As with solid propellant rocket engines, a further desirable feature when selecting the charge is that its burning rate should be insensitive to pressure over the range in which it is operated.

In addition to engines designed to give continuous thrust at a single level, some programmed thrust variations can be obtained by appropriately shaping the pressurising charge, or by using a charge consisting of sections of propellants with different burning rates. The engines can also be designed to provide to a limited extent the ability to be controlled by throttle during operation. It must be remembered of course that the solid charge will burn at a predetermined rate, or according to a predetermined programme. One relatively easy method of achieving a measure of thrust control can be used when a large pressure drop is available between the pressurised tank and the combustion chamber. A throttle in the liquid feed lines can then vary the flow over a range limited by the maximum pressure that the tank can sustain for the minimum thrust case, and the minimum pressure drop between the tank and the chamber for the maximum thrust case. This arrangement is particularly suitable for an engine which must provide an initial high thrust boost stage, immediately followed by a controllable thrust stage at a much lower level. Since the change in thrust level between the two stages of operation will also entail a change in the combustion chamber pressure, the pressure drop required for thrust control purposes is automatically available without the necessity of having to increase the maximum pressure level of the propellant tanks. The pressurising charge must be arranged to change its rate of burning at, or just prior to, the change of thrust stages of the engine. The selection of the final burning rate of the solid charge, together with the maximum available pressure drop between the tank and the chamber, will determine the range of thrust control that can be achieved.

Other methods of thrust control which entail venting of the excess pressurising gas below the maximum thrust condition can also be used. Whereas a wider range of thrust control can be obtained by this means, some care has to be exercised in order not to be wasteful in the amount of pressurising charge required. The charge must, of course, burn at a rate sufficient for the maximum thrust requirements, and for a duration consistent with the minimum thrust condition.

A further point which increases the versatility of these engines, is the ability to substitute alternative pressurising grains with differently programmed burning rates. In this manner the thrust characteristics of the engine may be changed by simply altering a small and relatively inexpensive component. This can be advantageous by allowing thrust programme changes considered desirable during engine or missile development, or enabling one type of engine to be used in alternative applications at different thrust levels.

The propellant selection available allows the units to be designed for use over a wide temperature range without the need for protective insulation or controlled storage conditions, and rapid cycling between the limits is readily accommodated. The solid propellant pressurising charge, which may normally have difficulty in meeting the wide temperature range often required, is readily protected without undue weight penalty by virtue of its small relative size and its protected position within the liquid propellant tankage.

The units can be handled freely and easily under field conditions and are robust enough to withstand considerable rough treatment. Probably the most damage-susceptible component likely to cause engine malfunctioning is the solid propellant charge. Again this is well protected by being buried within the liquid propellant tanks, and if there is the slightest doubt about its condition, it can be readily removed for inspection and can, if necessary, be quickly replaced by another charge of the same type.

Particularly suitable applications are those which are volume bound by adjacent components, and where maximum use can be made of the available volume by the ability of the liquid propellants to accommodate local intrusions, such as wing fixings, into the tanks. Also the space around the nozzle, which is often lost in solid propellant installations, can be fully utilised by the liquid propellants.

These units may be used with advantage in most air-launched missiles. The ability of the liquids to accommodate rapid changes of temperature and also readily absorb high heat inputs, allows the propellant tankage to become an integral external part of the missile, without the necessity for protective insulation. The high heat capacity of the liquids coupled with good convective heat transfer characteristics allows long duration external stowage with high recovery temperatures, and maintains the external skin cool. In air-to-air missiles simple thrust control may be used to compensate for the variation of drag with altitude, and to ensure that the missile will quickly attain and not exceed the speed dictated by aerodynamic heating.

Alternative Systems.—The use of a high pressure gas from a separate storage vessel to expel the propellants will always remain one of the most simple concepts for a liquid propellant engine, and can still be the best choice for some applications. The main disadvantage is the heavy weight of the gas storage vessel, coupled with the weight of commonly available pressurising gases, such as nitrogen or air, which is usually a significant proportion of the total. Use of the less readily available gas, helium, considerably minimises the latter effect. Even so, it is of interest to note that for very high thrusts and short durations this type of engine can provide significant weight advantages over the alternative solid rocket. This is largely because the propellant packing density of the solids is not only a function of the propellant burning rate, but also of the thrust and duration, and for high thrusts and short durations it can be quite low. However, for the short durations it is difficult to justify the use of a high pressure stored gas for expulsion purposes when it has been demonstrated that a solid propellant charge will

adequately and with greater simplicity serve the purpose. Perhaps a more satisfactory application for the stored gas expulsion system is the upper stage of a space vehicle, where a low chamber pressure can be used without loss of performance, and requirements for on-off or variable thrust may be necessary.

Other methods of pressurising the propellant tanks include the use of liquid monopropellant or bi-propellant gas generators, which may show some advantage especially where thrust variation is concerned. Again, however, it is generally difficult to justify their use against the more satisfactory operation of the solid propellant pressurising charge.

Finally, one propellant feed method still worthwhile considering is the turbo-pump. Packaged units employing this method are of a slightly different concept, being more complicated and requiring a different design approach. Indeed, in order that a truly packaged system may emerge and not just a storable liquid propellant system, a considerable amount of care must be devoted to obtaining the utmost simplicity. For instance, simple orifice control for setting the turbine speed and using the main propellants for bearing lubrication are desirable design features. Also, since the tank pressure will be low and cannot be used to operate the propellant valves, positive and reliable means such as cartridge-operated valves must be used. This type of unit is, of course, particularly suitable for long duration requirements where the benefits of chamber cooling and minimum propulsive system weight are the greatest.

Choice of Propellants

In order to qualify for use in packaged engines, the propellants must be capable of being satisfactorily stored in a sealed container over a range of temperatures consistent with the engine application. Table I gives details of a few suitable propellants. The lower temperature limit will be fixed by either the freezing point or the point at which the viscosity becomes unmanageable, and the upper temperature limit by either the normal boiling point or by the maximum pressure considered desirable in the sealed tank. This latter point is influenced by ullage space allowed during filling at normal temperature, the expansion coefficient of the liquid, and the liquid vapour or equilibrium pressure. Conversely it should be noted that the maximum temperature limit selected will directly influence the amount of propellant that can be stored in tanks of a fixed volume and hence the total impulse that can be obtained.

Table I.—*Physical Properties of some Storable Propellants*

Propellent	Freezing Temperature	Normal Boiling Temperature	Density at 20 deg. Cent.
	deg. Cent.	deg. Cent.	gm/c.c.
Oxidants :			
Inhibited red fuming nitric acid	−54	66	1·57
Chlorine trifluoride	−76	12	1·83
Nitrogen tetroxide	−11	21	1·45
Bromine pentafluoride	−60	40	2·48
Fuel :			
Unsymmetrical dimethyl hydrazine	−57	63	0·79
Hydrazine	2	114	1·01
Diethylenetriamine	−65	207	0·96
Mono-methylhydrazine	−52	88	0·88

The performance of typical propellant combinations is given in Table II. The suitability of the combinations for particular applications will depend upon the temperature range requirements and the relative importance of specific impulse and density. For volume limited applications it usually pays to sacrifice instantaneous performance for density impulse in order to obtain a high total impulse. In this respect use of bromine pentafluoride is of considerable interest. The other propellant combinations can be regarded as established systems, and here it will be seen that although diethylenetriamine yields a lower performance than unsymmetrical dimethyl hydrazine, it will produce a greater total impulse for fixed volume applications. A more suitable propellant combination for a specific application can very often be found by using mixtures of oxidants or fuels. For example, by increasing the nitrogen tetroxide content of nitric acid a higher density can be obtained at the expense of limiting the temperature range. Also by mixing mixtures of the various amines and hydrazines a more suitable fuel with respect to temperature range, performance, density or viscosity may be obtained.

Table II.—*Performance of Typical Propellant Combinations*

1000 lb per square inch absolute to sea level, maintained equilibrium

Combination	S.I.	Bulk Density	Density Impulse
	lb sec/lb	gm./c.c.	
I.R.F.N.A.—N_2H_4	283	1·28	362
I.R.F.N.A.—U.D.M.H.	276	1·26	348
I.R.F.N.A.—D.E.T.A.	269	1·37	369
N_2O_4—N_2H_4	292	1·22	356
N_2O_4—D.E.T.A.	278	1·27	353
ClF_5—N_2H_4	294	1·51	444
ClF_5—U.D.M.H.	280	1·38	386
ClF_5—D.E.T.A.	267	1·47	393
BrF_5—N_2H_4	244	1·86	454
BrF_5—D.E.T.A.	220	1·84	405

SOLID PROPELLANT DUAL THRUST MOTORS

By H. M. DARWELL‡

The requirement for dual thrust motors stems from a number of considerations. For short-range missiles launched in the neighbourhood of personnel or populated areas there are obvious hazards, both psychological and physical, from jettisoned boosts. The dual thrust motor does, however, have some positive advantages in that missile assembly can be simplified, reliability is usually improved and the missile is aerodynamically cleaner (if wrap-round boosts are replaced) or shorter (if a tandem boost is replaced). The chief disadvantage is that additional inert weight is carried after the first stage of burning.

The two general problems facing the designer of a solid propellant dual-thrust motor are : (1) in what ways can two thrust levels can be obtained ; and (2) how do the various ways compare in efficiency among themselves and also with the more conventional separate assemblies. Since dual thrust motors can be required to provide the equivalent of either a boost/sustain or an intermediate-acceleration/sustain system, the answer to these queries is required over a large range of thrust ratios.

The ways of obtaining two levels of thrust from a solid propellant motor can be classified into two divisions ; single chamber and double chamber motors.

Single chamber motors have cases similar to those used with motors of a single thrust level and two types of design are conceivable. Type " A " has a fixed nozzle configuration and the change in thrust level is a consequence of a change in pressure level, brought about by suitable design of the enclosed charge or charges. Type " B " has a variable nozzle, which is used so that greater efficiency can be obtained than in the type " A " system. The change in type " B " is again actuated by a change in burning behaviour of the charge but in this case a change in pressure level is not necessary.

‡ Summerfield Research Station, Imperial Chemical Industries, Ltd.

Two types of double chamber motors are also possible. Type " C " has an internal nozzle separating the two chambers and a single external nozzle and is really two motors in tandem. Type " D " is again two motors in tandem, but in this case the motors are isolated from one another, the rear chamber having its own separate nozzles and the gases from the forward chamber being passed through the rear chamber, by a transfer tube, to a central nozzle.

Single Chamber Motors with a Variable Nozzle. (Type " B ").—The single chamber motor with a variable (or rather two-setting) nozzle probably represents the ideal way of changing the thrust level. In this type of motor the throat area is decreased in size to correspond with a reduced mass flow rate in the second stage of operation (brought about by suitable charge design). By this means the pressure during the second stage can be maintained at a high level and improved efficiencies can be obtained, especially at low altitudes. It is also preferable (and for high thrust ratios almost mandatory) that the change in throat area should be accompanied by a change in the nozzle expansion cone.

A variable nozzle arrangement would provide two immediate advantages over the fixed nozzle system. Firstly the motor could be made to work efficiently during both stages, there being no loss in performance due to low pressure operation or incorrect expansion, and secondly there would be no obvious limit on the thrust ratio available. One slight disadvantage would be the extra inert weight at the rear of the missile.

Many efforts have been made to design a suitable system, but, as far as is known, no satisfactory arrangement has yet been evolved. A device which has shown promise and which is currently being developed at Summerfield Research Station is illustrated in Fig. 3. In this the second stage nozzle is retained beyond the first stage nozzle during the first stage of operation, suitable ports being provided to allow free passage of the gas. When the pressure level decays to a certain value at the end of the first stage, explosive bolts retaining the rear nozzle

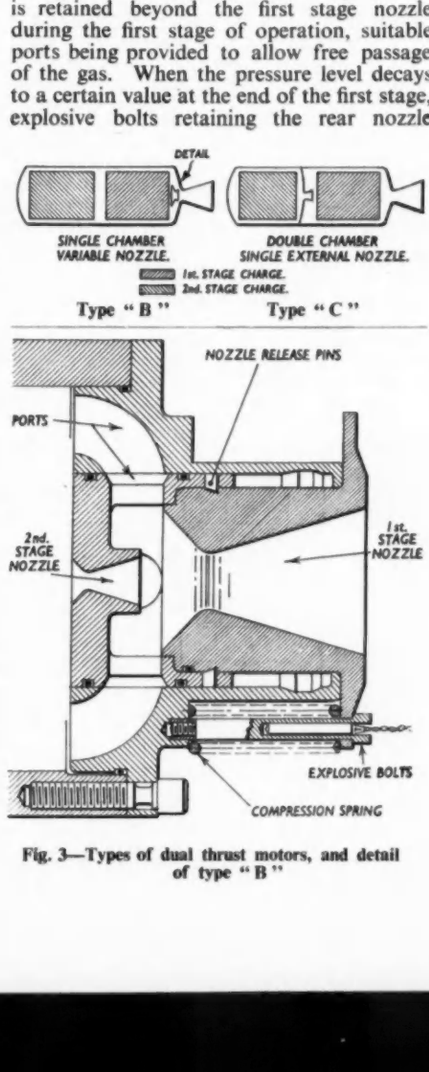


Fig. 3—Types of dual thrust motors, and detail of type " B "

are blown and the complete assembly is moved rearwards by the compression spring. The nozzle pins then become free, allowing the first stage nozzle to be ejected and leaving the second stage nozzle in its place. The main difficulties in this system are to control the rate of change-over and to safeguard against distortion caused by heating.

Little emphasis has been placed on the charge designs necessary for this type of motor, but, in order to work at similar pressure levels during the two stages, the change in mass flow rate must, in general, come mainly from a change in burning surface. This would probably require two charges, although in certain cases it might be possible to use a single composite charge. In addition it seems inadvisable to have any sliver from the first stage charge, as this might lead to high pressures when the nozzle is changed.

Dual Chamber Motors with a Single External Nozzle. (*Type "C"*).—This type of dual thrust motor is shown schematically in Fig. 3. Basically it consists of two motors in tandem, the two chambers being separated by an internal nozzle and the rear chamber having a single external nozzle. The charge in the rear chamber is consumed during the first stage of operation and both charges are ignited simultaneously.

The broad principle of operation is that, during the first stage, choking occurs at the rear throat and the arrangement behaves as one motor containing two charges. During the second stage, choking occurs at the internal choke, which governs the pressure in the forward chamber ; the reduced mass flow rate in this stage results in a decrease in thrust. There are obvious queries concerning what happens to the second stage gases as they pass through the rear chambers and the resulting performance and efficiency.

Theoretical studies confirmed by experimental firings have shown that the following mode of operation holds in general. During the first stage of burning choking occurs at the rear throat and, under suitable design conditions, the flow through the forward nozzle is subsonic. The motor then behaves as if it were a single chamber motor containing two charges, the rear choke governing the flow. During the second stage of operation choking occurs at the forward throat, this governing the flow in the forward chamber. The gases immediately downstream of the internal choke are at supersonic speed, but, providing the mass flow rate divided by the rear choke area is greater than a critical value, they are reduced to subsonic speed, either in the forward expansion cone or in the rear chamber, by a normal shock wave. Choking again occurs at the rear throat, which controls the pressure level in the rear chamber. The pressure in the rear chamber during the second stage can be calculated by dividing the forward chamber pressure by the ratio of throat areas, and the condition for choking to occur at the rear throat is that this pressure in the rear chamber should be greater than approximately 26 lb per square inch absolute. This latter condition holds for all practical cases. The thrust in the second stage is then as if the rocket motor were working at this reduced pressure level and exhausting through the rear nozzle.

It can be seen that the function of the central choke is purely to act as a pressure exchanger. The principle of operation is exactly analogous to that of a single chamber motor with a fixed nozzle, the change in thrust being brought about by a change in pressure level in the rear chamber. The only difference lies in the introduction of the forward choke which allows the forward propellant to be burned at any required pressure level.

This hypothesis has been checked extensively by experimental firings covering a wide range of conditions. Pressure measurements in both chambers and evaluation of thrust coefficients have confirmed these findings. In Fig. 4 the results from firings of 6in diameter experimental rounds are shown ; the pressure ratio in the two chambers during the second stage is plotted against the ratio of throat areas. During the course of these firings, which were carried out before the theory had been formulated, it was found that heat losses in the rear chamber and the value of the external nozzle expansion ratio could have a marked effect on the results. Consequently additional firings were carried out with the rear chamber insulated and expansion ratios closer to the optimum values for second stage operation ; this explains the scatter of the results.

A number of further points are worthy of mention. Firstly, it has been shown theoretically and experimentally that, in the first stage of operation, despite there being only a small pressure differential between the front and rear chambers, it is possible under suitable conditions to choke at the forward throat. This condition is attained if the pressure level in the forward chamber, considered as a separate motor choking at the forward throat, is greater than the pressure level from the whole motor choking at the rear throat only. This does not seem to have any detrimental effects ; the gases will be reduced to subsonic speed in the internal nozzle by shock formation. Fig. 5 illustrates this phenomenon.

The second point, which is in agreement with the theory, is that an expansion cone on the forward nozzle has no effect on the motor performance. Lastly, to obtain the full efficiency from the system, it is necessary to avoid heat losses in the rear chamber.

The main advantage of this type of motor is that there is no practical limit to the thrust ratio available, since the second stage propellant is not required to burn at the pressure level which is responsible for the second stage thrust. Motors with thrust ratios as high as 50 : 1 have been fired. Another advantage is that the pressure level in the forward chamber during the second stage can be chosen to suit the propellant.

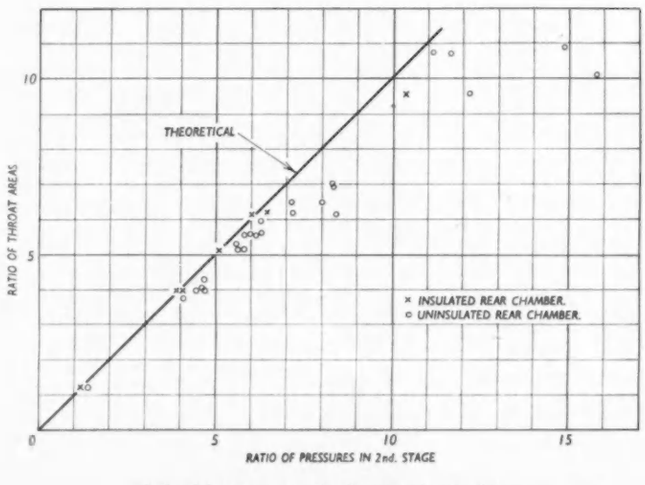
There are, however, two big disadvantages. First of all, additional weight is necessary to provide the central closure and to insulate the rear chamber adequately. Secondly, high thrust ratios involve low specific impulses in the second stage at ground level, because of the low pressure level in the rear chamber. This, however, does not hold at altitude.

Conclusions

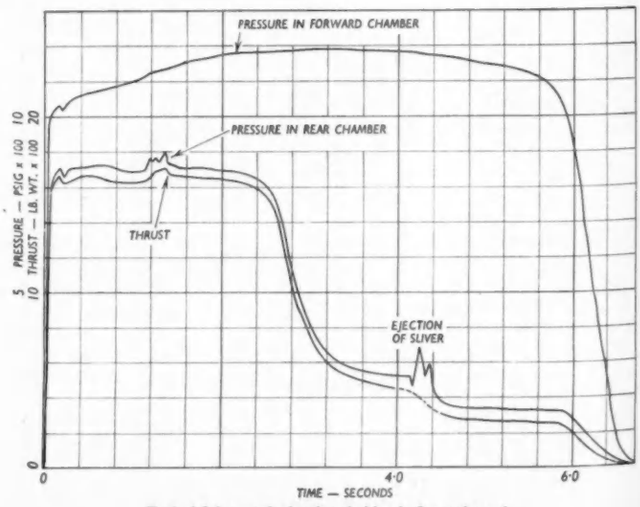
There are four basic methods of obtaining two thrust levels from a solid propellant motor. For thrust ratios up to about 8 : 1 the system using a single chamber with a fixed nozzle is preferred, this being simple and reliable and showing little, if any, weight disadvantages compared with the other types which have been developed. The possibility of employing a single composite grain gives added attraction to this system.

For thrust ratios in excess of 8 : 1, two types of dual chamber motors are possible. The preferred design, in general, is that using two independent motors in tandem. For high altitude operation during the low thrust stage, however, the design employing an internal nozzle is worthy of consideration. The latter type has been shown to operate, in principle, in a similar manner to a single chamber, fixed nozzle motor.

The single chamber motor with a variable nozzle is potentially the most efficient way of obtaining two thrust levels. No reliable method of changing the nozzle dimensions yet exists, however, although there are indications that a suitable mechanism can be developed.



Ratio of throat areas *v.* ratio of pressures in second stage.



Typical firing result showing choking in forward nozzle.

Figs. 4 and 5—Firings of double chamber, single external nozzle motors

SHORTER REPORTS

TABLE I—*Characteristics of the Income Distribution*

	Number of Engineers	Lower Quartile 1959-60 (1955-56)	Median 1959-60 (1955-56)	Upper Quartile 1959-60 (1955-56)
		£ £	£ £	£ £
1. All in the United Kingdom...	2,463	1,304 (950)	1,574 (1,181)	20,42 (1,600)
2. Age under 35	497	1,145 (837)	1,316 (953)	1,540 (1,110)
3. Age 35 to 39	658	1,292 (965)	1,501 (1,142)	1,789 (1,376)
4. Age 40 to 44	343	1,365 (1,040)	1,632 (1,281)	2,115 (1,659)
5. Age 45 to 54	585	1,419 (1,150)	1,778 (1,484)	2,474 (2,000)
6. Age 55 to 64	337	1,620 (1,216)	2,048 (1,652)	2,977 (2,305)
7. Age 65 and over	33	(Number too small for reliable figures)		
Professional Institutions : Corporate Members of the—				
8. Institution of Civil Engineers	514	1,269 (900)	1,515 (1,140)	1,968 (1,640)
9. Institution of Mechanical Engineers	1,031	1,302 (980)	1,567 (1,210)	1,994 (1,640)
10. Institution of Electrical Engineers	830	1,312 (960)	1,584 (1,190)	2,057 (1,560)
11. Institution of Chemical Engineers	326	1,737 —	2,175 —	3,087 —
Some fields of employment :				
12. Commerce and industry (not nationalised), excluding U.K.A.E.A.	1,134	1,303 (951)	1,567 (1,181)	2,044 (1,650)
13. Nationalised industries and U.K.A.E.A.	383	1,279 —	1,530 —	1,992 —
14. Civil Service	245	1,356 (1,066)	1,611 (1,265)	1,963 (1,545)
15. Local Authorities (excluding teachers) and Public Utilities	240	1,193 (824)	1,381 (968)	1,775 (1,360)
Regions :				
16. England and Wales	2,231	1,310 —	1,581 —	2,052 —
17. Scotland and Northern Ireland	216	1,248 —	1,500 —	1,933 —
18. All engineers in the U.K., but excluding members of the Institution of Chemical Engineers (for direct comparison with 1955–56 survey)*	2,375	1,297	1,562	2,009
Certain main occupations :				
19. Consultancy—private practice and salaried employment	141	1,280 —	1,572 —	2,470 —
20. Not in engineering occupations	90	1,879 (1,190)	2,714 (1,620)	3,700 (2,470)

* Omitted also are replies where membership of Institution is unknown. (These are included in, for examples, line 1 to 7.)

Remuneration of Engineers

IN a leading article on page 65 we comment upon an analysis of the 1960 survey of engineers' remuneration carried out by the Engineers' Guild and published in the January number of *The Professional Engineer*, the Guild's Journal, Reference was made in our pages a month ago to this survey when an outline of its findings was published. The sample upon which the findings are based covers over 4000 engineers, all corporate members of the Institutions of Civil Mechanical, Electrical or Chemical Engineers. We print below three tables of broken-down figures which seem to be particularly revealing. One of the tables breaks down the figures according to age, by institutions, by fields of employment &c. The others show the different salaries commanded by those who have and those who have not graduated.

TABLE II—*Graduates and Non-Graduates : Medians and Quartiles by Institution*

	Number	Lower Quartile £s	Median £s	Upper Quartile £s
I.C.E.:				
Graduates	312	1,289	1,542	2,043
Non-Graduates	197	1,238	1,461	1,785
I.Mech.E. :				
Graduates	270	1,566	1,942	2,627
Non-Graduates	751	1,246	1,479	1,800
I.E.E. :				
Graduates	347	1,457	1,798	2,450
Non-Graduates	474	1,259	1,461	1,798
I.Chem.E. :				
Graduates	209	1,802	2,264	3,094
Non-Graduates	109	1,638	1,993	2,983

TABLE III—*Graduates and Non-Graduates : Medians and Quartiles for Age-Groups*

	Number	Lower Quartile £s	Median £s	Upper Quartile £s
Under 35 :				
Graduates	225	1,215	1,371	1,587
Non-Graduates	266	1,101	1,268	1,490
Age 35 to 39 :				
Graduates	253	1,437	1,684	2,081
Non-Graduates	404	1,242	1,407	1,664
Age 40 to 44 :				
Graduates	118	1,633	1,941	2,617
Non-Graduates	219	1,301	1,509	1,846
Age 45 to 54 :				
Graduates	224	1,667	2,100	2,787
Non-Graduates	353	1,340	1,599	2,102
Age 55 to 64 :				
Graduates	138	1,900	2,367	3,850
Non-Graduates	192	1,492	1,835	2,491
All ages :				
Graduates	958	1,420	1,775	2,423
Non-Graduates	1,434	1,253	1,477	1,815

Interim Report on Glasgow Train Failures

IN view of public concern over the withdrawal of electric trains from the Glasgow suburban service, an interim report by Brigadier C. A. Langley, Chief Inspecting Officer of Railways, on the accidents of December 13 and 17 last which led to the withdrawal, was published on January 18 (H.M. Stationery Office, Price 1s.). Both accidents arose from transformer failures in the trains, and the report deals also with three other failures which had occurred since October 30. In all cases the failures occurred in the secondary windings. It was thought at first that they were due to severe and prolonged overheating, but subsequently examination revealed displacement of turns and " scuffing " of paper insulation without signs of overheating. The report comments that once the insulation broke down, severe arcing would occur, followed almost immediately by the " cracking " of the oil and the rapid build-up of gas pressure in the transformer tank. It is concluded that the design did not provide sufficient strength for the secondary winding to resist the very heavy electromagnetic forces which could be applied under the arduous conditions of electric traction.

Included in the report is an interim report made by Mr. F. J. Lane, of Messrs. Preece, Cardew and Rider, to the Chief Electrical Engineer of the British Transport Commission. This observes that transformers operating in association with mercury-arc rectifiers (as in these trains) are liable to experience onerous current and voltage conditions due principally to occasional backfires in the rectifiers and to current chopping which gives rise to overvoltages. The rectifiers in these trains are reported to have suffered backfires on numerous occasions as a direct result of overheating due to defective ventilating arrangements. Failures of control gear had also caused short circuits. It is accepted that breakdown of winding insulation has not been initiated by transient over-voltages (surges), and no evidence has yet been submitted to indicate that the failure of these transformers is due to any special conditions arising from the dual high-voltage electrification system.

Brigadier Langley's report states that the transformer was well built of high quality materials and passed the tests laid down by the Commission including the appropriate requirements of British Standards. Units in which transformers failed had covered between 1414 and 3939 miles of trial running. The transformer has now been redesigned, the turns of each secondary coil being of stronger construction. Rectifier ventilation troubles have been corrected and the faults in the control system are being put right. Additional reactance will be included in the circuits to limit abnormal currents liable to occur in traction service, and additional arrangements will be made to limit voltage surges (which have been detected in test conditions), and to protect the circuits fed from the tertiary winding. It is expected that trial running with new units will begin in March, but a date for resumption of public service cannot yet be forecast. Other modifications include alteration of the transformer oil system. The disposition of the pump will be changed, the size of the vent pipes to the conservator tank and to atmosphere will be increased and, although not essential for safety, the conservator tank will be removed from the guard's van and placed on the outside of the coach.

The final paragraphs of the report refer to failures of motors and other electrical equipment in Eastern Region rolling stock on the North-East London a.c. electrification. Their cause has not yet been established, but several alternative and possibly complementary theories are being investigated.

Electronic Recording of Bus Running

AN extension of trials with BESI (Bus Electronic Scanning Indicator) equipment to another five Central bus routes is announced by London Transport. The initial installation of this photoelectric system was described in our issue of January 17, 1958, page 95, and has been in use for three years on the route from Camden Town to Putney Heath. It enables a bus controller at a central point to see on which section of road a bus is running at any time, and the spacing of buses along the route as a whole. Since the original apparatus was fitted, experiments have taken place to determine the most suitable form of coded reflector for bus identification, and at present a series of prisms is being used instead of the earlier " cat's eyes." In its latest form, which is not necessarily final, the route number and running number of the bus are both coded on the identification plate so that one scanner can deal with more than one route. The scanning equipment has been partly transistorised, and time-multiplexing has allowed the number of telephone circuits required to be reduced considerably. The greater part of the equipment has been designed and patented by London Transport electrical engineers, and contracts for equipment for the new routes have been placed with General Precision Systems, Ltd., of Aylesbury. Three of the routes to be equipped pass through areas of congested traffic in the West End, City and Central London. It is hoped to equip the five additional routes before the end of this year.

Computer Exhibition and Symposium

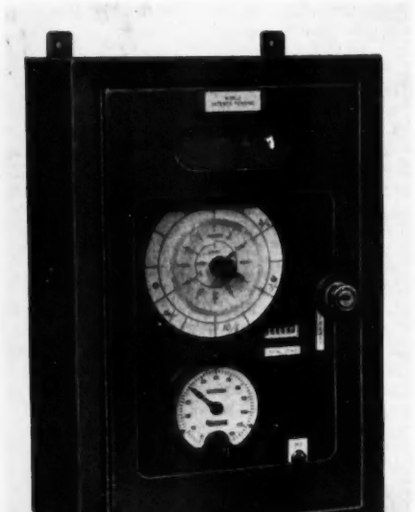
THIS year the Electronic Computer Exhibition will be held at Olympia, London, from October 3 to 12, and during this period, on October 4, 5 and 6, a Business Computer Symposium will also take place at Olympia. Emphasis will be placed on business applications of electronic data processing equipment and its importance to management. The exhibition and symposium are organised jointly by the Electronic Engineering Association and by the Office Appliance and Business Equipment Trade Association. On the first day of the symposium a number of speakers who took part in the earlier event of this kind in 1958 will explain the advances that have taken place since that time. The second day's proceedings will deal with the production and installation of a data processing system, and on the third day there will be a " brains trust " of users of small installations, and papers outlining the influence of new techniques now coming into sight.

SHORTER REPORTS *(continued)*

Bonus Indicating Clock

A NEW instrument known as the "Bonus Clock" has been developed by Rodene Electrical Co., Ltd. (for distribution by D. Robinson and Co., Ltd., 717, London Road, Hounslow, Middlesex), with a view to improving productivity and labour relations in mass production establishments. This clock is installed by each machine or other place where repetitive work is in progress and is designed to measure and display job-by-job the summated bonus earnings of the operative. It automatically indicates the bonus gained or lost on each single job and keeps a cumulative total of gains and losses to show at the end of a shift the operator's record. So long as the operator is earning bonus a green lamp on the clock panel is illuminated; should the rate of production slow down and exceed the set times a red light is switched on to indicate the fact to the operator and supervisor. The makers' state that with this method of keeping an operator fully informed of his production/bonus rate when on repetitive work a steady speed can be maintained to achieve the best consistent output.

The "Bonus Clock" is easily installed in any convenient position and simply connected to the a.c. power mains. It can be connected to the switch used to start the machine cycle or to a switch which can be operated by the operator at the start of each production sequence. At the end of a shift, or when a production batch is completed, a record is made by the supervisor of the bonus earned and items completed indicated on the clock, the dials of which are then turned back to zero ready for the next sequence.



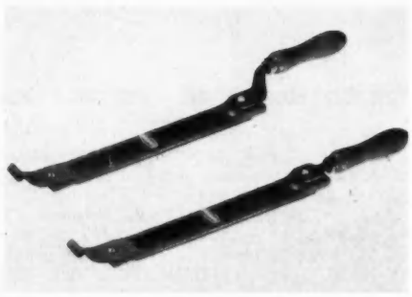
"Bonus clock" for piecework operatives

A "Bonus Clock" can be seen in our illustration. The lower of the two dials is graduated in seconds and its hand is set to the time allocated for each operation. The upper dial has central graduations of seconds and minutes, and its hands indicate the bonus time earned. A white surround on this dial can be marked with the money value of the bonus time, which is indicated by a second hand carried above the time hand. When an operation is completed in less time than that allowed, the hands of the bonus recorder are rotated clockwise the number of seconds equivalent to the time saved and the green signal light illuminated. Should the given time be exceeded the bonus recorder hands are driven backwards to deduct that number of seconds from the earned bonus time and the red light is switched on. A trip counter between the dials indicates the total number of piece parts completed in the working period.

[Reply Card No. E941]

Industrial "Surform" Files

FOR several years the "Surform" files and tools of Firth Cleveland Tools, Ltd., 7, Cleveland Row, London, S.W.1, have been widely used by both domestic and industrial workers for smoothing, cutting and shaping the softer metals, wood, plastics, fibre, &c. A more recent development of this firm is an industrial file for the harder metals, including mild steel, cast-iron, aluminium, copper, brass, &c., which is designed to stand up to long periods of continuous use without losing its efficiency. The renewable blade of this tool is generally similar in appearance to the familiar "Surform" blade, but it is made of a higher quality hardened and tempered steel with the teeth set further back with respect to each corrugation. As before, the blade corrugations control the depth of cut, but this setting back of the teeth has reduced their effective depth of cut to 0·003in to 0·004in, or less than half of that of the files made for softer materials. Clogging of the teeth is prevented as there is in front of each one a clearance hole through which the cuttings freely pass.



Straight and cranked handle "Surform" files having replaceable blades and interchangeable parts

These industrial files have all-steel bodies with removable forward guides and are fitted with either a straight wooden handle or a cranked handle adjustable round a full circle to facilitate filing in awkward positions. The two different models of files can be seen in our illustration. All parts of the tool, except the body, are interchangeable and are available separately.

In tests carried out by the maker on a filing machine, one of the new files removed 49in from a mild steel bar 1in square in 82,000 strokes. For this test a pressure of 22 lb was maintained on the file using a 6in stroke at a rate of fifty-five strokes a minute. When 49in of metal had been removed from the bar the file blade fractured, but it is stated that its teeth were still in good condition. At a recent demonstration we used one of the new files on a variety of metals and hard plastics and found them well balanced, light and easy to use—providing undue pressure was not imparted—whilst at the same time an appreciable rate of metal removal was maintained.

[Reply Card No. E942]

Computers in Lighting Design

IN the past the development and adoption of improved lighting methods have often been delayed because of the vast amount of numerical calculations entailed. But the electronic computer can reduce, by several orders of magnitude, the time and effort required to carry out these repetitive calculations, as was shown by H. E. Bellchambers, G. K. Lambert and H. R. Ruff in a paper presented to the Illuminating Engineering Society, in London, on January 9.

In this paper computer techniques were considered under two main headings—research aids and routine design application. As an example of research work the use of a resistance network analogue to determine surface luminance caused by lighted interiors was outlined and its possibilities in future routine designs was discussed. The inter-reflections of light in an interior setting and the effect of changes in surface reflectivities and room shapes were demonstrated with the help of an hydraulic analogue.

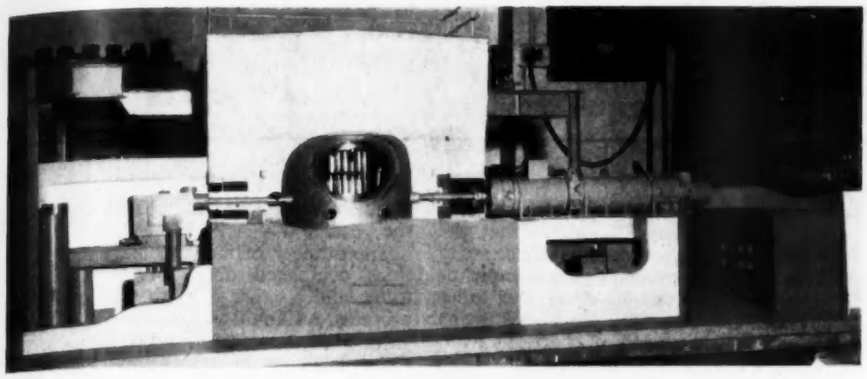
To prepare a problem for the digital computer it must be broken down and arranged in a logical sequence of simple instructions, known as a programme. By way of example the appropriate procedures for evaluating discomfort glare and for studies in street lighting were described in the paper. The evaluation of discomfort glare using the B.R.S. formula requires at least sixteen separate steps to determine the glare constant for one source, involving the use of trigonometrical tables and logarithms. Thus, in an installation of 144 lighting fittings one is required to make 1152 separate calculations for the single case of one known value of background luminance. Where, for example, this work has to be repeated twenty times for differing installations about 1¼ hours of computing time would save a man-year of working time.

In street lighting studies again the number of factors involved (such as intensity distribution, lantern spacing and height, road width and road surface reflection characteristics) may be introduced in a variety of combinations. Whereas a full week's time could be spent on calculating a single road brightness pattern by normal methods, by using a digital computer a great mass of valuable data can be obtained in a few hours of computing time. To illustrate the procedure the paper described the detailed planning of a programme for the simple problem of determining illumination on a plane normal to the incident light, at a series of points at varying distances using the well-known equation $E = I \cos^2 \theta / H^2$. The flow diagram showing the full sequence of operations was explained. The instruction sheet, in code, for a built-in programme for this problem, from the first instruction to print the date and serial number of the computation at the head of the result sheet, down to the final instruction which prevents the tail of the tape being inadvertently fed in first, was described.

The application of digital computers for the solution of routine problems and photometric data processing was discussed in the paper. A detailed description was given, as an example, of a routine procedure for area floodlighting design, in which a spherical chart was used to plan the scheme in broad outline and the computer then used to check, point by point, the whole installation. The method of handling floodlights having different intensity distributions and the determination of vertical and horizontal plane illumination were described.

Consulting Engineers' Centenary

THE business known to-day as Messrs. Sandberg, 40, Grosvenor Gardens, London, S.W.1, originated in 1860, when Christer Peter Sandberg, who was born at Venersborg, Sweden, in 1832, came to London and started to practise as a consulting engineer. C. P. Sandberg had been closely associated with the iron trade of his native country, and his metallurgical knowledge was valuable to him in the work he took up on arrival in London. In the same year as he set up in business Sandberg was appointed consulting



Model of "Pluto Loop A" in the Sandberg laboratories

and inspecting engineer in England for the Swedish State Railways; he held this position until his death in 1913.

C. P. Sandberg's main practice was in the field of railway engineering, especially in connection with permanent way materials, and he became a well-known authority on this subject. This investigation led him to the conclusion that improvements in rail design were needed, and in 1878 he brought out a series of new rail sections which were widely adopted, as were also the modified sections which followed in 1894. Sandberg's practice grew to include work for many British and foreign railways, in particular those of the Chinese and Siamese governments, and his work was recognised by decorations from Belgium, China, France, Russia and Sweden.

In due course C. P. Sandberg took into partnership his three sons, Christer Peter Sandberg, Oscar Fridolf Alexander (Alec) Sandberg, and Nils Percy Patrick Sandberg. The practice continued to be concerned mainly with railway work. The sorbitic process for surface heat-treatment of rails was introduced which, by localised heating and quenching, made it possible to provide a hard wearing surface, while the main body of the section remained unaffected. An *in situ* version of the process was developed for the treatment of tramway rails, and a further development, during the 1914-18 war, was applied to high-explosive shell forgings. In the war years the practice was closely concerned with war work, and Alec Sandberg and his brother Nils were both appointed to Government posts.

In between the wars, railway work remained the major preoccupation of the practice, and the development of rail treatment was continued further. The Sandberg oven, or controlled cooling process, introduced for rail treatment, was extremely successful, particularly in America. In 1943, for example, 43,866 rails were removed from the track due to transverse fissures. Since the introduction of controlled cooling, a total of less than ten transverse fissure failures in controlled cooled rails have been reported in the last twenty years.

From time to time, however, other projects besides railway work were undertaken, thus foreshadowing future developments, when the nature of the practice was to change to meet the needs of a changing world. In the 1920's the firm took a leading part in the salvage of £1,000,000 worth of gold from the sunken P. & O. liner "Egypt," one of the most difficult salvage operations attempted up to that time.

On the threat of war in 1939 the firm's laboratories at Grosvenor Gardens were taken over by the Ministry of Supply, and the firm soon found itself occupied with war work. After the war the need for changes in the business became obvious. When Mr. A. C. E. Sandberg, son of Alec, joined the firm in 1950 the three sons of the founder were dead, railway consulting work for China had ceased, and, as a result of the nationalisation of the British Railways, much of the home railway work had disappeared. Mr. A. C. E. Sandberg therefore introduced a new side to the business by developing the laboratories and providing specialised consulting, testing and inspection services in the fields of metallurgy, welding, chemistry and concrete. These services, it was, hoped would be of value to consulting engineers, contractors and manufacturers alike who might not normally have available the specialised knowledge and equipment required. The laboratories, hitherto equipped only for metallurgical work, were re-equipped and expanded to meet the new needs, and the staff was augmented accordingly.

To-day the railway practice continues, although it is no longer the principal activity. The firm maintains engineering inspectors resident throughout this country, Europe and the U.S.A., and now has a substantial practice of consultancy, testing and investigation, backed by laboratories at Grosvenor Gardens which cover the complete fields of concrete, metallurgy, welding, chemistry, physical testing and research. A workshop is attached to the laboratories for the manufacture of special equipment as required for testing or research purposes.

Typical specialist services provided by the firm in recent years include co-operation on the concrete aspects of the Forth and Severn road bridges, Park Lane improvements, and Hammersmith flyover. Welding supervision contracts include the Shell office block on the south bank of the River Thames, installation of new floors in the Victoria Tower, House of Commons, and the investigation of various methods of welding stainless steel to mild steel. Overseas concrete work includes co-operation on the reconstruction of H.M. dockyard, Malta, Rangoon Port Development and Wairakei "B" power station, New Zealand. Welding facilities have been developed for the Sudan Railways, and welding and concrete contracts are in hand in the Persian Gulf. The firm is also engaged on the metallurgical and concrete aspects of eleven nuclear reactors for the U.K.A.E.R.E., and the C.E.G.B. basic research into shielding concretes, gas and water tight concretes and experimental work for R.A.E., Farnborough, are in hand.

The accompanying illustration showing a model of "Pluto Loop A," with which the Sandberg business is associated, emphasises the change from the early days of railway work. The loop is being constructed by the de Havilland Engine Company for U.K.A.E.R.E., Harwell, and is intended to produce basic information for the design of the fuel rods for the O.E.E.C. "Dragon" reactor now under construction at Winfrith.

Pipe Laying by Helicopter

At the clay pits of the Associated Portland Cement Manufacturers, Ltd., at Cliffe, near Gravesend, Kent, clay is excavated by two electric grabbing cranes mounted on pontoons, and pumped as slurry through an intermediate pumping station to storage tanks at Cliffe jetty. From this point the clay slurry is taken by river tanker to the cement works at Swanscombe and Stone, about 9 miles away. As the excavation proceeded further from the intermediate station the slurry pipeline became overloaded, and a new line has therefore been laid.

The new pipeline, of 8¾in o.d. steel pipe, is 2000ft long. It was made by Stewarts and Lloyds, Ltd., and was flanged and finished in 20ft lengths by the Le Bas Tube Company, Ltd., which was also responsible for the laying operation. Because of the boggy nature of the ground on which the pipeline is laid, normal land transport of the pipe sections would have been difficult, and considerable manhandling would have been needed. It was therefore decided to lift the pipe sections by helicopter from a storage point at the nearest roadside, and transport them to the actual laying point. A Westland "Widgeon" helicopter, belonging to British United Airways, Ltd., was used. For carrying the pipe sections the aircraft owners devised a simple wire sling, carried from the cargo hook, and looped up to the fuselage on the return trips. Separate wire slings were used on the pipe sections, and by employing three sets of these short slings, one of which was normally carrying a pipe, while one was being attached to a new section, and the third was being returned to the loading point by the aircraft, the helicopter was kept almost continuously in the air. Very brief landings at each end of the lift were all that was necessary for attaching or detaching the sling.

It was originally intended that the aircraft should carry two lengths of pipe, each weighing 440 lb, on each trip, but after a few trial runs it was found that a quicker turn-round was possible with a single pipe, and the line was laid in this way. In practice the helicopter picked up a pipe every four minutes, and the line was completed in one day. At the laying point the aircraft was able to lower each pipe section to within a few inches of the required position, and very little manhandling was needed. With the pipe section, and a rubber gasket in position, two bolts were inserted and the nuts tightened roughly; the crew then removed the slings and took up their position at the end of the line ready to receive the next pipe section. Final bolting and tightening was done the following day. By orthodox methods the estimated time for laying the pipeline was ten to fourteen days; with the helicopter only one day was needed to get the complete line in position. Even allowing for the extra cost of using the aircraft, there was an estimated saving of one-third in the total cost.

Helicopter lowering pipe into position

INDUSTRIAL NEWS

Agricultural Machinery Exports

According to the latest figures published by the Agricultural Engineers Association, the total value of agricultural tractor and machinery exports for the first eleven months of 1960 was £117 million, of which agricultural tractor exports represented £79,000,000. The Association points out that the value of exports for eleven months is £12,000,000 higher than the previous record total, £105 million, for the twelve months of 1959.

The trend in the agricultural machinery industry in 1960, the Association says, runs counter to that of most other industries, with a substantial rise in exports accompanying a definite shrinkage in the home market. It may therefore be better placed to meet the difficulties of 1961, the Association feels, since performance in the Common Market suggests that exports may be more easily maintained than is likely to be the case with many other types of goods, and some recovery in home demand may take place as a reflection of the depressed level of sales in 1960.

Export Council for Europe

At its second meeting, held on January 11, under the chairmanship of Sir William McFadzean, the Export Council for Europe decided that nine teams of three men, composed of leading businessmen and industrialists drawn from its members, should leave during February to visit Britain's six partners in the European Free Trade Association, Austria, Denmark, Norway, Portugal, Sweden, and Switzerland, and also France, Italy and Spain. These "fact-finding missions" are to confer and work in close co-operation with the commercial representatives of the British Government, British trading interests, existing importers of British goods and other appropriate bodies. The remaining ten countries covered by the Council will be visited by similar sized missions in May and June.

Discussions by the teams on the spot will cover market needs, competition from other countries, questions of price, quality and design, the study of successful British export efforts together with investigation of complaints. The advisability of inviting buying missions to visit the United Kingdom will also be explored. The findings of these nine teams are to be collated immediately and used as a guide for the Council in its future programme of work.

The Export Council for Europe announces that it has decided to hold a national convention in the autumn of this year.

Iron and Steel

According to the Iron and Steel Board's production statement for December, 1960, signs of weakness in the home market for sheet, strip and tinplate have been appearing in the form of cancellations of orders and requests for deferment of deliveries. During the past few months, the Board says, the rate of ordering of finished steel has been a little below the rate of deliveries, thus reducing the total order load on the industry. Demand for many products, however, including plates, sections, reinforcing bars and merchant bars, remains strong, and the Board estimates that the mills have sufficient orders to ensure capacity working for several months. Because plentiful supplies are available from the other main producing countries, the Board warns that any significant increase in exports from the United Kingdom during 1961 will have to be secured against keen price competition.

During 1960 the total production of steel amounted to 24,305,000 tons, an increase of 20 per cent above the total for 1959, and 12 per cent above the previous highest annual figure reached in 1957. Steel production in December was at a weekly average of 451,100 tons. The total production of pig iron for 1960 was 15,763,000 tons, 25 per cent above the 1959 total and 10 per cent above the record total reached in 1957. The weekly production of 306,000 tons of pig iron in December, the Board says, was also a record for the month of December.

Throughout 1960, the Board says, supplies of raw materials for iron and steel making were generally adequate. This year, it is expected that scrap and pig iron from home sources will be sufficient for all steelmaking requirements apart from a minor import of scrap to meet certain problems of quality and distribution.

Coal in 1960

In a statement issued last week reviewing the coal industry's performance in 1960, Sir James Bowman, the retiring chairman of the National Coal Board, pointed out that during the year the Board had sold 10,000,000 tons more coal than it did in 1959. Power stations had consumed 5,000,000 tons more than in 1959, coke oven consumption was nearly 3,000,000 tons higher, and the domestic market took 2,000,000 tons more. Coal output, Sir James added, was held below the level of demand during the year, and the Board had lifted more than 6,000,000 tons from its undistributed stocks.

Productivity in the industry had continued its upward climb during the year, Sir James said, output per manshift for all workers at nearly 28 cwt. being nearly 4 per cent higher, and coalface productivity, at nearly 80 cwt, being 6 per cent higher than in 1959.

Compared with 1957, Sir James said, rigid economy and a high rate of efficiency represented savings in 1960 at the rate of about £50,000,000 a year, but even so, the Board had carried heavy financial burdens from stocking and from the loss of highly profitable opencast output, and in September had had to increase the price of coal by an average of 6s. 8d. a ton.

Referring to the fall in manpower in the industry, Sir James said that recruitment was resumed in most areas in the second half of the year and the loss of men fell to about 300 a week in the last weeks of 1960, compared with a weekly loss of 1400 during the first half of the year. Total recruitment in 1960 at 43,000 was about 16,000 higher than in 1959. The number of men on the books at the end of the year was 582,900, which compared with 634,000 at the end of 1959. During 1960, forty-four pits were closed, bringing the total number of closures in the last three years to 136. All but 250 of the 15,000 men affected by the 1960 closures were placed in jobs by the end of the year.

The number of major colliery reconstructions completed during 1960 was thirty-three, and another 127 schemes are still in progress. Capital expenditure during the year, the statement says, was about £90,000,000, which was about £20,000,000 less than in 1959, the peak year of expenditure. The Board does not expect that there will be any reduction in the level of expenditure in the plans previously announced for the period up to 1965.

Commenting on the industry's prospects for 1961, Sir James said that subject to any unforeseen changes in the economy it had been estimated that total consumption would be about the same as in 1960. Production would be regulated at a level which would enable demands for different types of coal to be met, while allowing further reductions in the Board's stocks. Efficiency was now at the highest peak ever reached, Sir James went on to say, and higher levels would be attained in 1961, when there would be a further rapid increase in mechanical output and concentration of working. The industry, he added, would improve its competitive strength during this year.

Apprentice Awards

The British Junior Chambers of Commerce have announced details of its British Apprentices Award scheme for 1961. The awards take the form of travelling scholarships and are offered to selected apprentices. The scheme has been extended this year, first by raising the age limit for technical and commercial apprentices, and secondly by making subsidiary awards to all regional winners who attend the national finals. These subsidiary awards, it is stated, will probably be in the form of a short visit to an industrial centre in Europe.

There are three major travel awards this year. The "Technical Apprentice Award" is open to all technical apprentices who will have completed their contracts on or before August 31, who are not over twenty-four years old at that date, and who have obtained Higher National Certificate in any branch of engineering or technology, or the Diploma of Technology. The award covers nine months in Australia. The "Craft Apprentice Award" is open to all craft apprentices who will have completed their contracts by August 31, who are not over twenty-two years old at that date and who have obtained Ordinary National Certificate in any branch of engineering or technology, or Intermediate London City and Guilds I or II Class. The award covers six months in Canada. The "Commercial Apprentice Award" is open to all commercial apprentice who will have completed their contracts by August 31, who are not over twenty-four years old at that date, and who have obtained Higher National Certificate in Commerce, or equivalent professional qualifications. The award covers six months in the U.S.A.

The winner of each award is given a free return passage to his country of destination. During his stay there appropriate employment is found, and where possible, educational facilities are also arranged. A grant is also made to cover clothing, travelling and social occasions.

PERSONAL AND BUSINESS

Appointments

MR. NORMAN WELCH has been appointed sales manager of A. G. Wild and Co., Ltd.

MR. ROBERT CARTER-PEDLAR has been appointed sales manager of Photoelectronics (M.O.M.), Ltd.

MR. W. G. J. APPLETON, M.I.Mech.E., M.Inst.F., has been appointed a director of Stordy Engineering, Ltd.

MR. J. W. RIDGEWAY has been elected chairman of the Radio Industry Council in succession to Mr. E. E. Rosen.

DOWTY GROUP, Ltd., has announced that Mr. W. Spires has been appointed to the board of Dowty Rotol, Ltd.

AIR VICE-MARSHAL W. E. OULTON has joined the board of E.M.I. Electronics, Ltd., as director responsible for Ministry work.

MR. F. G. HUGHES has been appointed southern sales manager in the London office of Robert Dempster and Sons, Ltd.

MR. E. W. DIXON has been appointed assistant works manager at the Greenock, Scotland, factory of I.B.M. United Kingdom, Ltd.

MAJOR WILLIAM LOGAN, general sales manager of Avo, Ltd., has been appointed to the board of the company and has assumed the responsibilities of sales director.

MR. HECTOR V. SLADE, M.I.Mech.E., managing director of the Garrard Engineering and Manufacturing Company, Ltd., has joined the board of Plessey International, Ltd.

HUNTING AIRCRAFT, Ltd., announces that Sir Percy Hunting has relinquished the chairmanship of the company and has been succeeded by Sir George Edwards, Hon. F.R.Ae.S.

DR. P. H. SYKES, F.R.I.C., M.I.Chem.E., director of research and development of the Reed Paper Group, has been appointed deputy managing director of Albert E. Reed and Co., Ltd.

MR. WALTER ANDERSON GALBRAITH, A.M.I. Mech.E., has been appointed sales director of the Yale and Towne Manufacturing Company's British Materials Handling Division at Wednesfield, Staffs.

BABCOX AND WILCOX, Ltd., states that Mr. C. H. Davy, resident director of its Scottish Works since 1951, is returning to London where he will take up duties at the head office on February 1 as an executive director.

MR. WALTER WASHBOURNE has been appointed general manager of the excavator division of Newton Chambers and Co., Ltd. He succeeds Mr. R. J. Palmer who will continue as a local director until his retirement.

CAPTAIN J. G. HOPCRAFT has retired as chairman and managing director of Parsons Chain Company, Ltd., and British Wire Products, Ltd. He has been succeeded by the deputy managing director, Mr. Ronald S. Searle.

KUWAIT OIL COMPANY, Ltd., states that following the appointment of Mr. L. T. Jordon as assistant managing director of Kuwait Oil Company, Ltd., in which appointment he will continue resident in Kuwait, Mr. E. C. Masterson has been appointed the company's general manager, London.

SIR WILLIAM ARROL AND CO., Ltd., has announced that Mr. John H. Huntley, chairman, retired on December 31, 1960, after fifty years' service. He has been succeeded by Mr. W. I. French. Mr. J. P. Barrett and Mr. John Y. Danks, M.I.C.E., have been appointed joint managing directors.

ASQUITH MACHINE TOOL CORPORATION, Ltd., announces that Mr. J. Atherton has joined its subsidiary company, William Asquith, Ltd., as a director and chief engineer. Mr. A. Johnson is relinquishing his position as chief engineer of William Asquith, Ltd., but is retaining his seat on the board.

THE MINISTRY OF TRANSPORT announces that Mr. H. N. Ginns, A.M.I.C.E., has been appointed divisional road engineer of the north-eastern division in succession to the late Mr. J. G. Taylor, M.I.C.E. Mr. R. A. H. Allen, A.M.I.C.E., has been appointed to succeed Mr. Ginns as deputy chief road engineer, Scotland.

THE PULSOMETER ENGINEERING COMPANY, Ltd., announces that Mr. F. B. Duncan has relinquished the chairmanship of the company at his own request and has resigned from the board of directors. Sir Charles Key has retired from the board for personal reasons. Mr. Harold T. Collinswood has been appointed chairman of the company.

FLETCHER MILLER, Ltd., has announced the appointment of four new directors. These are Mr. J. R. Bickerton, chief chemist at the Hyde plant; Mr. J. Birchenough, works manager at the Hyde plant; Mr. R. A. Miller, divisional sales manager in the north London division; and Mr. S. V. Tilley, senior technical representative in the Midlands and South Wales. Mr. D. W. Howe has been appointed northern area manager, engineering division.

MUREX WELDING PROCESSES, Ltd., states that Mr. H. Martin, home sales manager, retired in December, 1960, on reaching retiring age after thirty-eight years' service with the company. Mr. R. E. H. Bell, assistant home sales manager for the past ten years, has been appointed home sales manager. Mr. K. Leevers, A.M.I.E.E., A.M.I.Mech.E., and Mr. P. Hobbs have been appointed assistant home sales managers (technical). Mr. S. E. Smith has been appointed plant sales manager.

THE ENGLISH ELECTRIC VALVE COMPANY, Ltd., has appointed Mr. M. Esterson manager of the newly-formed high-power klystron division. The following have been appointed assistant divisional managers: Mr. J. R. Bagnall, small klystrons; Mr. G. O. Chalk, microwave research; Dr. J. C. Firmin, memory tubes; Mr. M. A. Gates, large valves; Mr. E. D. Hendry, photo-electric tubes; Mr. R. E. Lake, cold cathode tubes; Dr. A. H. Pickering, magnetrons, and Mr. W. D. Rivers, small valves.

POWELL DUFFRYN, Ltd., announces the following appointments: Mr. W. H. Sharland, deputy chairman of Powell Duffryn, Ltd., has joined the board of Gulf Radiators, Ltd.; Mr. A. C. Hazel, managing director of Hurseal, Ltd., has been appointed to the board of Janitor Boilers, Ltd.; Mr. K. M. D. Johns has joined the Group, from Mobil Oil Company, Ltd., and has been appointed to the boards of Janitor Boilers, Ltd., Hurseal, Ltd., and Gulf Radiators, Ltd.; Mr. R. H. Stewart, managing director of Janitor Boilers, Ltd., has joined the board of Hurseal, Ltd.; Mr. R. Turner, managing director of Powell Duffryn Technical Services, Ltd. and deputy chairman of Powell Duffryn Carbon Products, Ltd., has joined the boards of Janitor Boilers, Ltd. and Gulf Radiators, Ltd.

Business Announcements

THE MINISTRY OF TRANSPORT has announced that Mr. S. H. Leake has resigned as a part-time member of the London Transport Executive.

C.I.G.R.E., British National Committee, states that its new address is c/o the Electrical Research Association, Cleeve Road, Leatherhead, Surrey.

THE HOLMAN GROUP, of Camborne, Cornwall, has opened new offices and a show room at 8, King Street, Bristol. The branch manager is Mr. J. C. Holman.

RICHARD THOMAS AND BALDWINS, Ltd., Redbourn Section, P.O. Box No. 7, Redbourn Works, Scunthorpe, Lincs, states that its telephone number has been changed to Scunthorpe 3451.

DIVERSEY (U.K.), Ltd., 42–46, Weymouth Street, London, W.1, states that as from February 1, it will operate a new division in the United Kingdom, to be known as the metal industries division.

THE GENERAL ELECTRIC COMPANY, Ltd., announces that the headquarters of the installation equipment group has moved into a new office building alongside the group's switch fusegear factory at Four Ashes, Wolverhampton.

THE ENGLISH ELECTRIC COMPANY, Ltd., has formed a new reinforced plastics division at Freckletons Works, Mill Lane, Warton, Lancs (telephone, Freckleton 521). Mr. Charles Hayes is the manager of the new division.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., has announced that Mr. F. Baxendale, formerly manager of valve and semiconductor sales, electronic apparatus division, retired on December 31, 1960, after thirty-seven years' service.

SMALL AND PARKES, Ltd., Hendham Vale Works, Manchester, 9, announces that on January 30 its depot at Sheffield will move to a new building at 101, Scotland Street, Sheffield, 3. The telephone number, Sheffield 25529, is unchanged.

WELDING SUPERVISION, Ltd., and CATHODIC CORROSION CONTROL, Ltd., wholly-owned subsidiaries of Constructors John Brown, Ltd., have been amalgamated and their services will now be provided by a single company. Corrosion and Welding Engineering, Ltd. The directors are Mr. R. M. Wynne-Edwards, Mr. C. C. Bates, Mr. R. A. Lowe, Mr. H. M. Powell, Mr. J. A. R. Staniforth, and Mr. H. D. Walker.

Contracts

DAVY AND UNITED ENGINEERING COMPANY, Ltd., has received an order worth over £1,250,000 for a four-high, 39in and 60in by 132in plate mill for the Clydebridge Steel Works of Colvilles, Ltd.

THE DE HAVILLAND AIRCRAFT COMPANY has contracted to supply propellers of 18ft diameter for the prototypes of the twin-"Tyne" Transall C-160, which are due to fly in 1962. Although only six propellers, excluding spares, are involved, it is admitted that the contract approaches £500 000 in value.

RICHARD COSTAIN, Ltd., has been awarded a contract valued at £786,000 for constructing the new physics and mathematics building at the University of Nottingham. The total value of the firm's work at the University is now over £2,750,000. The structural consultants are Messrs. Ove Arup and Partners.

STEPHENSON CLARKE, Ltd., has placed an order with the Burntisland Shipbuilding Company, Ltd., for an open/closed shelter deck cargo ship of 10,200 tons deadweight. The dimensions are: length between perpendiculars 420ft, breadth 56ft 6in, depth 36ft 6in and propulsion will be by a four-cylinder Doxford oil engine of 6600 b.h.p.

THE GENERAL ELECTRIC COMPANY, Ltd., has received orders for two ore-handling plants, one for the Scunthorpe Works of the Appleby-Frodingham Steel Company and the other for the Ravenscraig Works of Colvilles, Ltd. At Appleby Frodingham the plant, ordered through Head Wrightson Iron and Steelworks Engineering Ltd., comprises an 8-bed blending plant and about 15,000ft of conveying equipment for the sister plant. At Ravenscraig the plant has been ordered in three sections, covering stockyard extensions, sinter plant conveying equipment and limestone and lime handling plant.

DAVY AND UNITED ENGINEERING COMPANY, Ltd. (a member of the Davy-Ashmore Group), and the Brightside Foundry and Engineering Company, Ltd. (a member of the Brightside Group), have secured a contract worth just over £2,250,000 to build rolling mills for the new Tinsley Park Works, Sheffield, of the English Steel Corporation, Ltd. The contract, which is part of a £26,000,000 project, is for plant primarily designed to produce high quality alloy and special carbon steel billets. It consists of a 42in by 102in blooming and slabbing mill, two 32in by 84in reversing billet mills, and an extensive range of billet finishing equipment. Provision is being made in the layout for a third billet mill stand to be added later. The blooming and slabbing mill will be able to roll slab ingots of stainless steel weighing 10½ tons, for the neighbouring hot strip plant of Shepcote Lane Rolling Mills, Ltd., as well as blooms for the Tinsley Park Mill.

Miscellanea

CORRECTION.—In the note on the "wrecking" crane built by Cowans, Sheldon and Co., Ltd., on Plate 4 of THE ENGINEER of January 6, 1961, the lifting capacity of the auxiliary hoist should have been given as 56 short tons at 29ft 3in radius and the total weight of the crane in working order as 200 short tons.

PACKAGED AIR CONDITIONERS.—A range of packaged air conditioning units specifically designed for laboratories has been introduced by Carlyle Air Conditioning and Refrigeration, Ltd., London. These laboratory conditioners have cooling capacities from 29,000 to 54,000 B.Th.U. per hour, as well as an electric heater battery and humidifier. Temperatures and humidities over a wide range of conditions can be obtained within close tolerances for laboratory work.

Death

WE record with regret the death of Commander J. R. Patterson, O.B.E., D.S.C., R.N. (retired), which occurred suddenly on January 9. Commander Patterson, who joined the Parsons and Marine Engineering Turbine Research and Development Association in 1952, upon the completion of thirty-six years' service in the Royal Navy, was the technical secretary of the Association and as such was secretary to all the technical committees and well known to members of marine engineering firms in this country.

CONTINENTAL AFFAIRS

by Our Continental Editor

High Speed Lifts of Centre International Rogier

ONE of the largest and most modern buildings in Europe is nearing completion after a construction period of three years. The "Centre International Rogier" (architect, Jacques Cuisiner) occupies a site of about 90,000 square feet at the Gare du Nord in Brussels. It will contain about ninety-five shops on three levels, and 155 flats of about 1000 square feet each, provided with large balconies. Some 600 offices, covering a total area of 250,000 square feet, will be occupied by a staff of about 5000 people and an exhibition and festival hall of 45,000 square feet will be incorporated. Amongst other facilities will be a bus station as well as a car park for 1000 vehicles, distributed over five floors, complete with service station. A medical centre with pharmacies, a large tavern as well as a panoramic restaurant, occupying the twenty-seventh and twenty-eighth floors, will be provided. On the twenty-ninth floor a visitors' terrace and on the thirtieth floor a club-terrace will form the top of the building. Furthermore, a large theatre will be moved from its present place in the "Résidence Palace" into this building, where it will occupy six floors and provide 800 seats. In order to run this theatre efficiently, a rehearsal room with 300 seats, reception rooms, &c., will be located nearby.

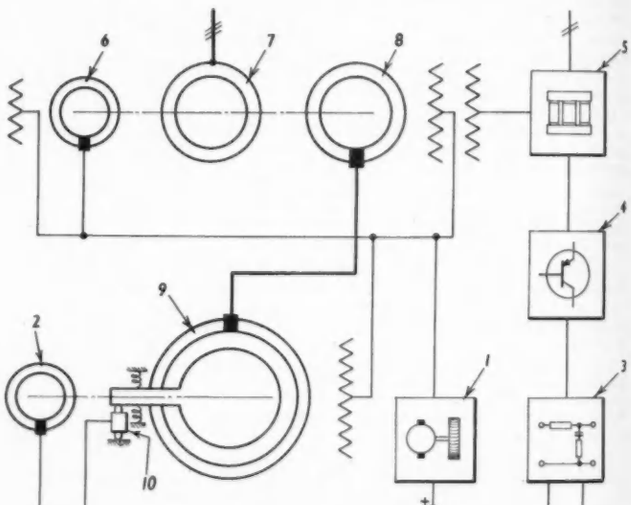
This complex building, occupied daily by 6000 persons, will reach a total height of 385ft. It will be divided into three distinct parts, namely a tower with thirty floors, facing the Place Rogier, a curved main block, reaching a height of 280ft, grouping twenty-eight floors with flats only, and the back part, towards the railway, consisting of eight floors for parking, the festival hall and some annexes with offices along the Rue du Progrès. Structurally, the building is of a very interesting design; for example reinforced concrete has been used up to the twenty-fourth floor, while above a structural steel design without inside columns carries the remaining five floors.

Access to the different sections of the building is provided by twenty-two passenger carrying lifts with a joint capacity of over 200 persons. The curved block, containing the 155 flats, is being serviced by seven passenger lifts, each carrying six to seven persons at a speed of 300ft per minute, while the tower office section is served by six passenger lifts of which five have a capacity of thirteen to sixteen passengers and a speed of 500ft per minute. One of these six lifts will be a very fast speed installation, carrying thirteen passengers at a speed of 1100ft per minute to the restaurant floors. The direct trip from the ground floor to the twenty-ninth floor restaurant will, therefore, take not more than twenty-five seconds.

In the very early stages of planning, a traffic analysis was made to ascertain vertical traffic conditions at all hours. Considering that this building will accommodate mainly offices and luxury flats and that some large companies will occupy several floors, lifts will have to cope with typical morning and afternoon rush hour traffic. Some of the lifts will take care of flat tenants, and visitors to the festival hall and public restaurants. Specially designed electronic controls will make a constant "moment by moment" assessment of the traffic density and direction, and automatically select and switch into operation one of a number of "programmes" to suit these particular conditions, thus ensuring optimum performance at all times.

The diversified use of the building does not allow a centralised group of lifts as would be desirable, and lifts will have to be distributed among the various sections. Duplex groups and individual installations are to handle various independent sectors of the building. However, in the central office tower section, lifts No. 5 to 10 are concentrated, of which three lifts, namely Nos. 5, 6 and 7, are connected in what the maker calls its "Supermatic" four-programme control system, while No. 10 is the special fast lift, serving the restaurant and panoramic floors only; this is claimed to be the fastest lift in operation in Europe. Table I gives the principal data for the sixteen main passenger lifts.

"*Transitronic*" *Drive*.—The main feature of this fast speed lift and the other six high-speed installations is the "Transitronic" type electronically controlled gearless hoist developed by the maker. A patented electronic control circuit steplessly regulates the movement of the lift over the whole speed range, ensuring smooth speed transitions and accurate stopping. Our illustration shows the drive diagrammatically. Control and amplifier systems incorporate semiconductors and transducers with a virtually unlimited life.



Circuit diagram of "Transitronic" lift drive

Principle.—The reference voltage generator (1) produces a pilot voltage proportional to the desired travelling speed. This reference voltage is continuously being compared with the actual voltage of the tachometer generator (2), the latter varying in direct proportion with the actual lift speed. The difference between the two voltages is applied to the stabiliser (3) and amplified by the transistor amplifier (4). The stabiliser prevents the occurrence of speed oscillations. The transistor amplifier controls the magnetic amplifier (5), which in turn feeds the main field winding of the generator (8), and transmits a voltage dependent upon the field current to the lifting motor (9). The field of the lifting motor is fed directly from the exciter (6) and remains constant as to strength and direction. The motor speed is approximately proportional to the voltage supplied from the generator. The load measuring unit (10) enables the lifting motor to create a torque sufficient to balance the load while the brake is still applied.

Operation.—The field of the lifting motor is built up immediately a landing or car push

TABLE I—*Passenger Lifts in Centre International Rozier Building*

Passenger lift No.	Load, lb	Speed ft/min	Travel ft, approx.	No. of stops	Control system	Machine
5	2500	500	265	26	Triplex "Supermatic" programme control	Ward Leonard gearless
6	2500	500	265	26		Ward Leonard gearless
7	2500	500	265	26		Ward Leonard gearless
8	2000	500	320	29	Duplex collective-selective	Ward Leonard gearless
9	2500	500	320	29	Duplex collective-selective	Ward Leonard gearless
10	2000	1100	320	4	Collective-selective	Ward Leonard gearless
11	1100	300	215	9	Down collective	A.C. geared with electronic speed control
12	1100	300	205	8	Down collective	A.C. geared with electronic speed control
13	1100	500	265	7	Collective-selective	Ward Leonard gearless
14	1100	300	215	9	Down collective	A.C. geared with electronic speed control
15	1100	300	205	8	Down collective	
16	1100	300	154	6	Down collective	
17	1100	300	144	5	Down collective	
18	2000	300	126	10	Collective-selective	Ward Leonard geared
3a	1100	250	97	10	Duplex collective-selective	A.C. geared multi-speed
3b	1100	250	97	10		

button is pressed. When the field current reaches about 75 per cent of its maximum value, load measuring commences. The load measuring unit creates a voltage, the magnitude and direction of which are determined by the unbalance of the lift. This voltage, suitably amplified, builds up a proportional current in the Ward-Leonard circuit. Together with the field of the lifting motor, this current sets up a torque corresponding exactly to the load in the lift car and thus completely relieves the brake. The whole of this initial operation, which lasts about 0·3 seconds, takes place while the door of the car is closing. As the door is locked, an impulse is sent out to release the mechanical holding brake. At the same time the reference voltage builds up from zero, and this actuates the electronic system, accelerating the lift in accordance with the pilot or reference speed curve. Once the rate speed is attained, it is held constant by the control circuit, irrespective of load. The retarding period is initiated prior to stopping in the conventional manner by the lift control system. The voltage of the generator is controlled across the amplifier section in accordance with the reference voltage and causes electric braking of the lifting motor, until the prestopping speed of the lift reaches a minimum value. An inch or two before the lift car reaches the desired floor level, the machine slows down to the micro-levelling speed, and then stops altogether, with a levelling accuracy of $\pm\frac{1}{16}$in ($\pm$5mm). The mechanical holding brake closes only after the lift has finally stopped.

An automatic electric re-levelling device is built into each " Transitronic " control unit. If for some reason the cage remains outside the floor level limit of $+\frac{1}{16}$in ($\pm$5mm), a photo-electric cell fitted on the car is brought into operation by means of which the lift is immediately levelled at micro-speed. In this case also the load-measuring unit is first actuated, which is an essential preliminary to precise electrical re-levelling.

Programmed Group Control System.—The " Supermatic " group control system incorporates a preselected traffic programme for each of four main traffic conditions which are met with in busy buildings such as office blocks, viz. " Up " peak traffic, " Down " peak traffic, " Up and Down " interfloor traffic, and low density night traffic. These programmes are put into operation by a computer on the basis of the actual traffic demand. The number of persons using a certain lift is measured in terms of the ratio of the weight carried to the design load by a load-sensing device. The number of buttons pressed on the different floors is also registered. These and other items of information are fed to the computer, which reacts accordingly.

" Up " peak traffic takes place in the office building at the time offices open. All the passengers desire to travel from the ground floor to their office floors. Congestion or confusion in front of the lifts must be avoided. The " Supermatic " control system registers these traffic conditions automatically and selects for each group of lifts a building sector to be served. All car calls are answered, independently of the time they have been registered, in the natural sequence of floors within the sector. If one or more lifts should for a certain length of time be prevented from giving the necessary service, the sector limits are automatically adjusted to provide equal service to all floors.

Visual signals above lift doors can be seen from a distance by an arriving passenger and leave no doubt as to which lifts will give service to the floor he wishes to travel to. This saves passengers the annoyance of having to dash about from one lift door to another.

Lifts are sent to their destinations at short intervals, reducing the time for return trips and limiting waiting time for passengers. Normally one car is ready and waiting for passengers at the main floor.

Balanced interfloor traffic is predominant between the two peak traffic periods. The control reacts to this pattern by changing over to routine service, i.e. cars leaving the ground floor at regular intervals. The length of the intervals is directly dependent on traffic density and all cars proceed to the top floor. This interfloor traffic management is stated to be extremely flexible and sensitive to the traffic density and conditions. Lifts are taken into operation only to such extent as is necessary to save long waits for the passengers, thereby reducing running costs. Heavier " up " traffic is a condition arising when the number of passengers travelling in the " up " direction is temporarily larger than the number of " down " passengers. Individual cars then operate according to different schedules, so as to return as quickly as possible to the ground floor and again to be available for a new trip. The length of dispatching intervals is again dependent on traffic density. Heavier " down " traffic has to be met if temporarily more passengers are travelling down than up. The distribution of calls to the various cars and the spacing of the cars is automatically adjusted by the system along the same lines as for the heavier up programme to achieve the most favourable distribution of cars within the group to satisfy the down traffic.

" Down " peak traffic occurs in the office building at noon and in the evening when offices are closing. The majority of passengers wish to travel from their office floors to the ground floor. All floors must receive equal service, i.e. waiting time must be practically equal at all floors.

At the beginning of such traffic condition, the control switches over fully automatically to a " down " peak programme. Calls are distributed among the various lifts according to a selected pattern. Every car travels up to a different floor and commences to collect passengers and to take them down to the ground floor. As soon as a car is full, it ceases to stop at further call floors but proceeds instead directly to the ground floor. Having discharged its passengers, the car returns to the call floor by-passed first during the previous trip, provided that in the meantime such floor has not already been served by another car. As a result of this fully flexible traffic pattern, waiting times are practically equal on all floors, since no floor can be continuously by-passed by full cars and no car is bound to preselected fixed zones. All lifts support each other in collecting down traffic. All floors are served equally quick y, so that a so-called " forgotten man " provision is unnecessary.

After hours, at night and during holidays, vertical traffic requirements are usually very small. Mostly one lift is capable of handling the whole of the traffic. All other lifts are then automatically disconnected to save unnecessary power consumption. Should traffic increase slightly, a second lift is automatically brought into operation.

The lifts were designed and installed by Schindler and Co., Ltd., Lucerne and Brussels, (associated in Great Britain with Platt-Schindler Lifts Limited, 8 Spring Gardens, Cockspur Street, London, S.W.1.)

Bascule Bridges at Derendorf Goods Station

For the last few years, the German Federal Railway (DB) has been investing annual sums of the order of DM.2200 million in order to modernise and rationalise its operations. Within the domain of improvements in efficiency must also be reckoned measures taken to reduce the possibility of accidents. Our accompanying illustrations show part of the goods yard at Dusseldorf–Derendorf. In these loading and unloading bays it was important to provide trolleys, forklift trucks and other vehicles with quick yet safe connections between the platforms.

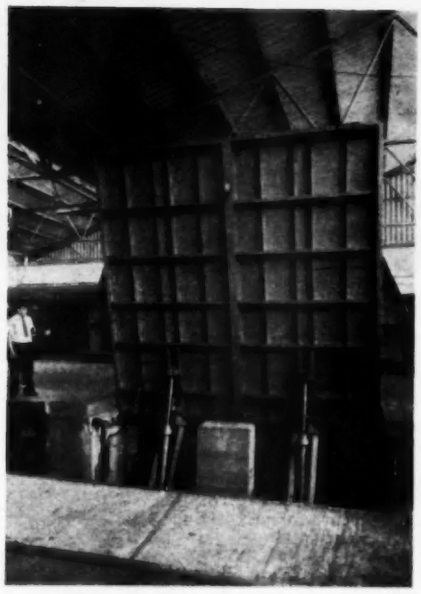


Fig. 2—Bascule bridge in raised position, revealing hydraulic operating jacks. The fulcrum is set well back from the track

This was achieved by a number of bascule bridges which have recently been installed. These bridges are electrically controlled and hydraulically operated. Lowering one of the bridges automatically closes the track concerned to train traffic.

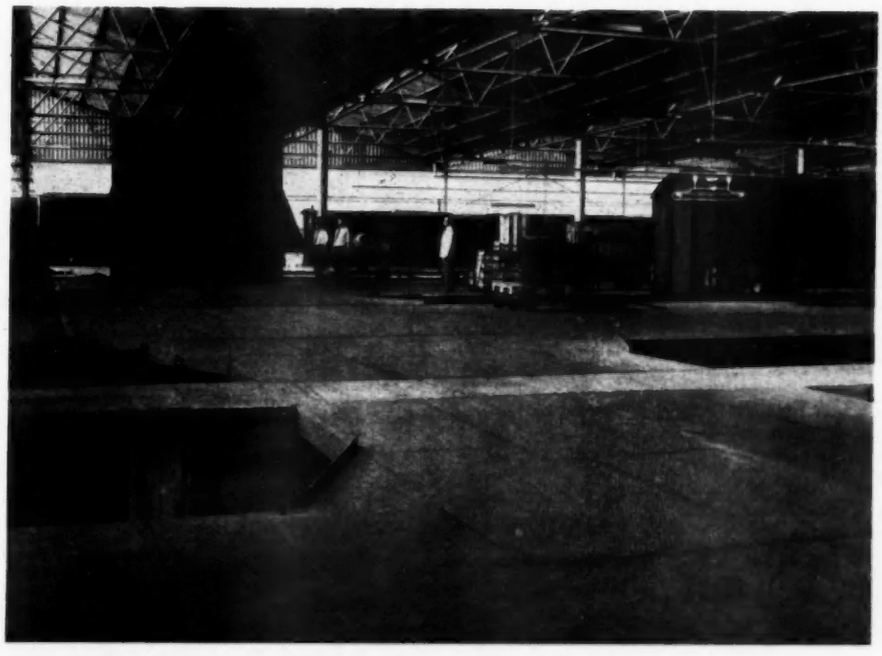


Fig. 1—Trollies and personnel can safely travel between the different platforms of Derendorf goods station by way of the bascule bridges which have been provided. Note gusset sections with guards

CONTINENTAL AFFAIRS *(continued)*

Fig. 1—30/7·5-tonne travelling crane of 26m span. The bridge girder is fabricated from aluminium alloy

Lightweight Overhead Travelling Cranes

Claimed to contribute an important step forward in the lightweight construction of overhead travelling cranes is a 30/7·5-ton workshop crane spanning 26m which Maschinenfabrik Augsburg–Nürnberg AG. (M.A.N.), Nuremberg, recently supplied to a Hamburg shipyard.

The problem with which the shipyard was faced was to replace an existing 20-ton crane by a 30-ton crane without increasing the wheel loads, so as to avoid rebuilding the existing 250m long gantry.

By adopting a box-section mono-girder designed in conjunction with composite light alloy/steel construction, the maker succeeded in achieving a weight saving of more than 60 per cent over the previous 20-ton crane by the new crane bridge design alone, in spite of the 50 per cent higher capacity, so that the requirement of the shipyard could be fully met.

The material for the welded box girder which transmits loads due to bending and torsion was aluminium alloy Al Mg5 F24. This material has good welding properties and its strength is unaffected by the welding process. The rails for the crab at three corners of the girder section and a reinforcing strip at the fourth corner were made of steel and considered as fully stress bearing in the design.

Although the crab frame which is in the shape of an inverted L was made of steel, because its weight is relatively small in proportion to the total weight of the crane, it was possible by the use of high-grade materials and good design of the mechanical equipment to keep the trolley weight slightly below the weight of the previous 20-ton trolley.

It is stated by the maker that the box-section mono-girder design will afford a substantial reduction in weight even if the crane is made of steel. Thus, two turbine house cranes of 100 tons capacity and 40m span each which M.A.N. supplied to a power station in Northern Germany (Fig. 2) are more than 30 per cent lighter than conventional designs.

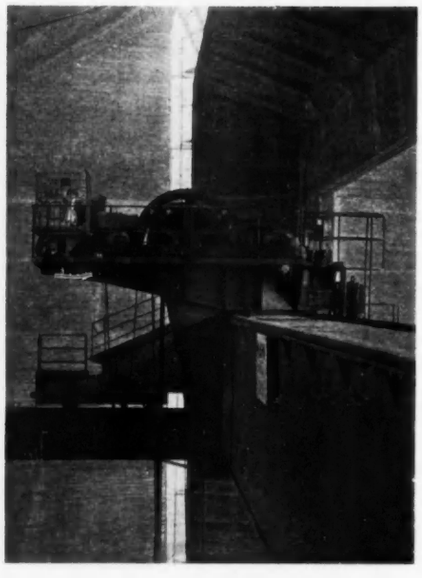
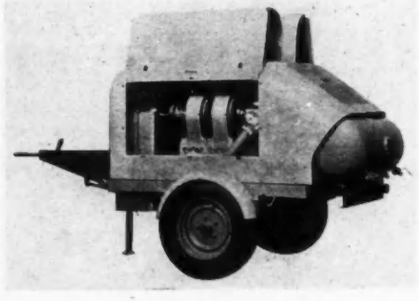


Fig. 2—100/25/10-tonne machine hall travelling crane of 40m span in mono-girder design

Portable Air Compressor

We have received details of the model " JW 440 KF " portable compressor made by Jenbacher Werke A.G., Jenbach (Tyrol) and now available in this country from Chamberlain Plant, Ltd., Crown Works, Southbury Road, Enfield, Middlesex. In this machine, which is shown in the accompanying illustration, the engine and compressor are combined to form one integral unit.



Portable air compressor

The two diesel cylinders of 125mm bore and 145mm stroke are arranged vertically in line, while the two compressor cylinders of 135mm bore and 140mm stroke are horizontal and in line on the same side. The compressor connecting-rod is mounted in an auxiliary bearing in the big-end of the engine connecting-rod. Having the engine and compressor cylinders mutually at right angles is stated to produce complete balance and therefore exceptionally quiet running.

The large suction and delivery disc valves of the compressor cylinders are concentric, with the delivery valve on the outside. This helps to cool the delivery valve by means of the suction air in addition to external cooling from the water jacket, or fan air in the case of the air-cooled version.

At the normal operating speed of 1500 r.p.m. the engine develops 40 h.p., the compressor delivering 4·2 cubic metres per minute (178 cubic feet per minute) of free air at a pressure of 6 to 7 atmospheres (85 lb to 100 lb per square inch). The engine speed is adjustable in operation between 1000 and 1500 r.p.m. Before reaching the receiver the compressed air passes through an annular radiator fanned by a centrifugal blower on the flywheel. Air aspirated by the engine/compressor unit is purified in oil bath filters. The volume drawn in is checked by a regulating valve which is controlled by the pressure prevailing in the air receiver. When the air chamber is fully charged suction is stopped and the engine is caused to idle by its governor.

The air chamber, with a capacity of 5·2 cubic feet, is welded and hydraulically tested for leaks. It is fitted with a safety valve for 112 lb per square inch working pressure, three cocks and a drain cock for condensed water. The compressor unit is started by means of electrical equipment comprising starter, preliminary heater, dynamo, regulator and a heavy duty battery. The fuel system contains a fuel tank of 9 gallons capacity, fuel pipes, microfilter, injection pump, two one-hole injection nozzles (mixture formed in pre-combustion chamber) and leak oil return pipes. A sprung, single-axle, welded frame with pneumatic tyres carries the unit together with all accessories including tools. Protection against the weather is obtained by the steel sheet covering with large side flaps which may be locked to prevent unauthorised interference. The drawbar with standard hitching eye is detachable and an adjustable low bar is provided. Over-run brake, hand brake, brake stop light and lighting equipment for the number plate complete the equipment and permit the compressor to be towed day or night on the road. The compressor has a net weight of approximately 2856 lb, and a gross weight of approximately 3528 lb.

Measurement, Control and Automation Exhibition

During the period May 9-17, the " Mesurcora " Exhibition will be held at the C.N.I.T. Palace, Place de la Défense, Paris. This international exhibition, which is taking place for the first time, will be devoted to measurement, control, regulation, and automation. Some 600 exhibitors from thirteen countries will be showing their products in an area of 35,000 square metres. Also included in the event will be the 58th Annual Exhibition of the Société Française de Physique. Concurrently, an international congress is to be held in Paris with the general theme of " Recent Progress in the Fields of Measurement, Control, Regulation and Automation, resulting from the co-operation of Electric, Electronic, Mechanical, and Nuclear Techniques." Full information may be obtained from the Secretariat, 40, rue du Colisée, Paris (8e).

Hardening Colloquium

The firm Paul Ferd, Peddinghaus, Gevelsberg, Hasslinghauserstrasse 160, will hold its 12th International Colloquium on " Flame Hardening and Localised Heat Treatment " on March 6 and 7, at the Haus der Technik, Essen, Hollestrasse 1. Full information and programme may be obtained by application to the organiser.

THE AMERICAN SCENE

By Our American Editor

Gauge Block Developments at the National Bureau of Standards

No. III—(*Continued from page 63, January 13, 1961*)

Stability Measurements

THE data obtained from the observation of stability are presented in Figs. 10, 11, 12 and 13. In these figures, time elapsed since final heat-treatment is plotted against change in length. Each plotted point has an upper and lower limit which is the estimated precision of the determination. This estimate was based upon the statistical information derived from the test itself. When the frequency distribution of all measurement residuals of an inter-comparison test indicated a nearly normal distribution and when the residuals were limited to a range within three times the calculated standard deviation of a single reading, the evaluated precision of the inter-comparison test was estimated to be three times the computed standard deviation of the final result. When the range of the frequency distribution exceeded that to be expected from the calculated standard deviation, a factor of four times the standard deviation was applied as an estimate of precision. Large loads at the grinding shop and time spent accumulating sufficient blocks for an efficient lap load, in some cases, caused considerable delay in the interval between final heat-treatment and final lapping. In addition, procedures for measuring the blocks were being developed simultaneously and were not ready until after some of the blocks had been completed for some time. Plotting the time elapsed since final heat-treatment compensated for the delays and put each block on a more comparable basis.

Commercial Gauge Blocks

As a basis of comparison, a total of seven 2in steel gauge blocks, two from each of three manufacturers and one from a fourth, were purchased on the open market and incorporated into the measuring programme. The blocks were ordered as "AA" grade, the best quality available. The results obtained from observing the stability of these blocks are shown in Fig. 11.

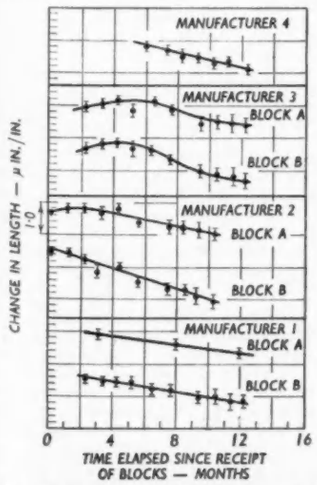


Fig. 10—Stability of commercial gauge blocks of "AA" grade

The abscissa for this figure is the number of months elapsed since purchase. While it would have been more desirable to have plotted the months elapsed since final heat-treatment, such data were not available. All of the commercial blocks have become shorter, although block A of manufacturer 2 and blocks A and B of manufacturer 3 initially indicated a tendency towards growth. There is also a considerable degree of similarity between the stability characteristics of paired blocks from each manufacturer. The apparent overall stability of these blocks, extrapolated to a period of one year, ranges from a minimum of $-0{\cdot}7\times10^{-6}$in per inch to a maximum of $-1{\cdot}9\times10^{-6}$in per inch. The average change in length for the seven blocks is $-1{\cdot}1\times10^{-6}$in per inch per year, which is adequate to maintain size within the current Federal specification for only two years. It is standard procedure of some manufacturers to finish their blocks on the positive side of the tolerance to allow for what is claimed to be wear. This procedure could extend the time within tolerance for the average of these blocks to four years, assuming a uniform continuance of the contraction.

Type 52100 Steel

The results of stability measurements on hardened 52100 steel gauge blocks are shown in Fig 11 and include blocks hardened either by martempering or by direct quenching. The six curves plotted in section A represent stability characteristics of blocks given the lowest final temper and stress relief so as to obtain a hardness of 65 Rockwell C. Each block that was measured during the first five months became shorter, and became nearly stable for the remaining period of observation; block T-337 showed a slight tendency to decrease in length with increase in time over the entire period of its observation. The initial contraction was more pronounced in those blocks measured soon after final stress relief, and very small or absent in blocks whose initial measurements were made five months after heat-treatment. All six curves have similar characteristics, regardless of whether the blocks they represent were martempered or quenched. The overall change in length computed on the basis of one year ranges from $-0{\cdot}2\times10^{-6}$ to $-0{\cdot}7\times10^{-6}$in per inch. The average change for the six blocks is $-0{\cdot}4\times10^{-6}$in per inch, a value indicating approximately three times more stability than the commercial blocks. A more realistic approach is to compute the length changes after the sixth month, since the blocks appear essentially stable once the initial rate of contraction has subsided. On this basis the minimum change, extrapolated to one year, is 0·0 and the maximum $-0{\cdot}3\times10^{-6}$in. per inch per year. The average is a very low $-0{\cdot}1\times10^{-6}$in per inch per year, indicating about ten times greater stability than the commercial average, and well within the goals of $\pm0{\cdot}2\times10^{-6}$in per inch per year set for this investigation.

The four curves in section B and the four in section C represent the stability of blocks that were given final tempers and stress relief treatments at temperatures in excess of 250 deg. Fah. to reduce nominal hardness to 62 Rockwell C and 60 Rockwell C respectively. These stability results were not anticipated, for it was initially reasoned that the higher tempering and stress relief temperatures would produce a more stable structure and stress pattern. Instead, the eight blocks represented by the curves in B and C appear less stable than those in A. The directly quenched blocks in B and C (T-377, T-378, T-384, T-386) have not been observed sufficiently long to ascertain the exact shape of their stability curves. Although the curves for the four blocks have been drawn linearly, they all exhibit what could be a tendency to flatten during the last four measurements. Nevertheless, the shapes of the curves are undoubtedly different from the curves of the matching martempered blocks in

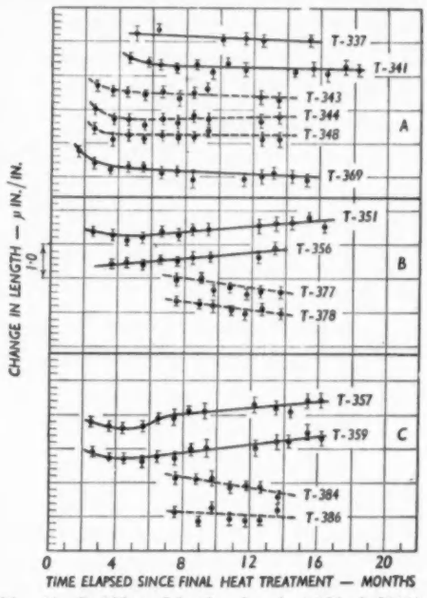


Fig. 11—Stability of hardened and stabilised 52100 steel gauge blocks

sections B and C (T-351, T-356, T-357, T-359). The four directly quenched blocks were the only blocks whose non-gauging surfaces were ground perpendicular to the 2in dimension; all others were ground parallel.

The large surfaces adjacent to the gauging surfaces of two hardened 52100 gauge blocks were analysed for residual stresses by the Timken Roller Bearing Company, in accordance with the X-ray techniques of Christenson and Rowland. One of these blocks had been heat-treated for maximum hardness (65 Rockwell C) and ground in a manner identical to blocks T-343, T-344, and T-348. The other was prepared with a hardness of 60 Rockwell C in a manner identical to that used for blocks T-384 and T-386. The block tempered at 250 deg. Fah. to a hardness of 65 Rockwell C had a residual compressive surface stress of 14,400 lb per square inch parallel to the grinding direction and 60,200 lb per square inch perpendicular to the grinding direction. The block tempered at 465 deg. Fah. (60 Rockwell C) had residual compressive stresses of 20,100 lb per square inch parallel and 70,500 lb. square inch perpendicular to the grinding direction. Thus, the data indicate that the compressive stresses in the surfaces of the blocks actually increase with an increase in the tempering temperature from 250 deg. to 465 deg. Fah. Therefore, it is postulated that the process of tempering at temperatures in excess of 250 deg. Fah. caused a structural change within the block

THE AMERICAN SCENE *(continued)*

which was accompanied by a contraction. The surface stresses, however, were not relieved at a rate sufficiently high to counterbalance the internal contractions, with the overall result that the compressive stresses in the surface were increased by the increase in tempering temperature. The net result seems to have been an unbalance between the subsequent structural and lattice changes and the distribution and size of residual stresses, which in turn has contributed to a growth of four blocks (T-351, T-356, T-357, T-359) in sections B and C. On the other hand, grinding the other four blocks at a 90 deg. direction has shifted the maximum observed compressive stress by 90 deg. It is suggested that the observed shrinkage in these blocks is caused by the change in the orientation of the stress patterns.

Type 410 Stainless Steel

The results of stability measurements on annealed and nitrided 410 stainless gauge blocks are shown in Fig. 12. The four curves plotted in section A represent the stability characteristics of

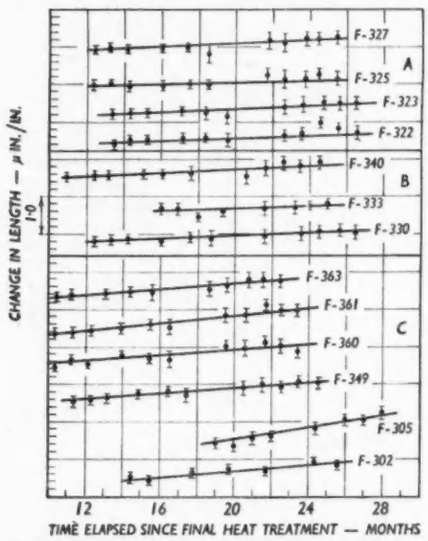


Fig. 12—Stability of nitrided, initially annealed type 410 stainless steel gauge blocks

blocks nitrided by the two-stage process whose non-gauging surfaces were not ground or otherwise machined after nitriding. The entire group exhibits similar stability characteristics; the slope of each curve is almost the same. There was practically no deviation from linearity during the entire thirteen month period of observation, although a tendency towards additional flattening may be indicated in the last four measurements. It is unfortunate that no measurements could be made prior to the twelfth month after heat-treatment, so that the behaviour of these blocks during the first year could have been observed. The overall change in length computed on the basis of one year is a consistent $+0{\cdot}2\times10^{-6}$in per inch per year. This value just meets the degree of tolerance sought in this investigation. Based on a one year interval any one of these blocks is about three times more stable than the best of the commercial blocks tested, five times more stable than the average, and nine times more stable than the least stable.

The curves in section B represent data from three blocks which were nitrided by the conventional single-stage process. The preparation of these blocks also differs from that in section A in that the white layer on the non-gauging surfaces was ground off, so as to leave a hard, bright, nitrided case. The stability of these blocks is almost the same as for those in section A. The range is $+0{\cdot}1\times10^{-6}$ to $+0{\cdot}3\times10^{-6}$in per inch per year with an average of $+0{\cdot}2\times10^{-6}$. The curve for F-333 has an extremely low slope, but this block has been observed for only nine months and the trend of the last four points is towards greater slope. The average of this group is equivalent to that of group A, but there is slightly more scatter. The blocks represented by the curves in section C were nitrided by the single-stage process and differ from those in B in that all of the nitrided cases were removed from the four non-gauging faces by grinding. These blocks exhibit the same trend towards uniform linear growth, but the rate is higher. The range is $+0{\cdot}4\times10^{-6}$ to $-0{\cdot}9\times10^{-6}$in per inch per year with an average of $-0{\cdot}6\times10^{-6}$. Except for block F-305 each curve has a similar slope, and again the nonconforming curve was drawn through fewer points of observations. The last two or three points plotted for each curve, except F-305, indicate a downtrend. The average of this group is more stable than the most stable commercial block observed.

If the assumption is made that the 410 stainless, as annealed, has a normal tendency to grow, and the data support this assumption, then the improved performance of the blocks with nitrided non-gauging faces could be explained. The nitrided surfaces could serve as a restraining jacket, which would be more effective with increasing thickness. Thus, the blocks whose non-gauging faces were not ground at all had the thickest case and grew the least, those whose white layer was removed had a thinner case and indicated slightly less uniform stability characteristics, and those whose case was removed entirely had maximum growth. The investigation is being extended to evaluate further the effect of the thickness of nitrided cases on non-gauging faces.

Residual stress determinations were made on the non-gauging surfaces of nitrided 410 stainless steel blocks. A block processed similarly to those in section A had residual tensile stresses of 3000 lb per square inch parallel to the 2in gauging length and 2800 lb per square inch perpendicular to the gauging length. A block processed like those in section B had a residual tensile stress of 31,000 lb per square inch in the direction parallel to grinding (stresses perpendicular to grinding not determined), while a block representative of those in C had compressive stresses of 1300 lb per square inch parallel to grinding and only 900 lb per square inch perpendicular to grinding. Except for the fact that the relief of residual compressive stresses would be expected to cause growth, no apparent relationship can be seen between the reported residual stresses and the rate of growth of the different blocks. In actuality, the values of residual stress reported for blocks in A and in C are very low and should not have contributed materially to length changes.

Hard Coatings

The results of stability measurements on both annealed 52100 and annealed 410 gauge blocks with hard coatings are given in Fig. 13. The stability characteristics of 52100 steel coated only on the gauging surfaces with thermal-sprayed nickel-chromium-boron alloy are represented in section A. The steel was heated after coating to fuse the particles and some degree of hardening occurred as a result. The hardness of the steel after the fusion treatment was 43 Rockwell C. Both blocks have similar characteristics, and both grew slowly at a linear rate. T-309 grew $0{\cdot}5\times10^{-6}$in per inch, extrapolated to one year, and T-312 grew $0{\cdot}3\times10^{-6}$in per inch per year.

The blocks represented in section B have been flame plated with tungsten carbide on gauging surfaces only. Both of the 52100 blocks (T-301 and T-302) have similar stability characteristics. Initially they expanded at a rate similar to 410 stainless block F-317 in section B, but they have exhibited more stable characteristics during the last six months of observation. The 410 blocks have grown rapidly much more so than the nitrided blocks in section C of Fig 12. This particular comparison is made because the latter blocks were ground on the non-gauging faces and stress relieved at 975 deg. Fah. in the same manner as the blocks illustrated in section B.

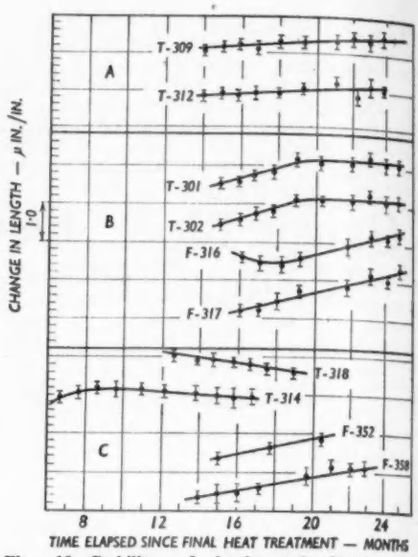


Fig. 13—Stability of hard-coated 52100 steel blocks (T) and 410 stainless steel blocks (F)

Therefore, the core material in each group has essentially the same structure and residual surface stress pattern and the difference in behaviour can be attributed to the cases.

The blocks whose stability characteristics are shown in section C were chromium electroplated. T-314 and T-318 were plated on all six surfaces and the plating on the non-gauging faces was ground sufficiently to obtain the desired dimensions. Blocks F-352 and F-358 were plated on the ends only. The 52100 blocks are reacting similarly to one another and the two 410 stainless blocks also have curves similar to each other. The former are contracting although there was an initial increase in T-314. The chromium plated 410 stainless blocks are increasing in size at a fairly rapid rate.

Overall Observations

The most stable groups of blocks for the period observed were the nitrided 410 stainless steel blocks with all or portions of the nitrided cases left on all surfaces. These blocks had stability characteristics that met the goal set for this investigation: a maximum dimensional change of 2×10^{-6}in per inch per year. These blocks proved to be resistant to normal atmospheric corrosion and accepted the best lapped finish of any block tested. The reproducibility of performance in these blocks, as evidenced by the uniformity of slope and low spread of individual values in each group, was also excellent. There was no apparent deviation from linearity in the dimensional changes of any of the nitrided 410 stainless blocks, but all showed some tendencies towards growth.

The best of the blocks made from 52100 steel were those hardened and stabilised at the high hardness of 65 Rockwell C. The repetition obtained within this group was excellent, and included both directly quenched and martempered blocks. If the first six months after final heat-treatment are disregarded, these blocks exhibited even greater stability than the best of the 410 stainless. All of the hardened 52100 blocks on which observations were made during the first six months contracted initially and then stopped contracting, or expanded according to the tempering or grinding treatment given them.

Several of the blocks with hard coatings were more stable than the commercial blocks tested. Both the sprayed Ni-Cr-B and the plated tungsten carbide apparently caused an overall growth, but on the 52100 blocks the growth was small or had subsided. The principal undesirable feature noted with the Ni-Cr-B and tungsten carbide coatings was the high porosity of surface obtained on lapping, which was readily apparent to the unaided eye.

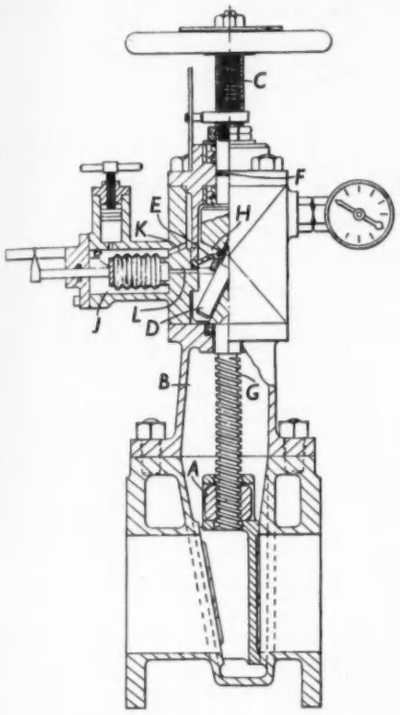
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

VALVES

855,822. April 14, 1959.—FLUID CONTROL VALVES, J. Samuel White and Co., Ltd., Medina Road, West Cowes, Isle of Wight, Hampshire. (*Inventor : Terence Fursdon Crang.*)

This invention relates to valves of the glandless type, in which the closure member is operated by a rotary driving device hermetically sealed to prevent fluid escaping. Such valves find their main application in controlling radioactive, volatile, explosive or exp nsive liquids, vapours or gases. In this design, as shown in the drawing, the valve gate is attached to



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a nut *A* which co-operates with a shaft in a tension cavity *B* leading from the valve chamber. This shaft *G* constitutes an inner rotary member and is mounted in a ball bearing thrust race at the outer end of the cavity, being thus prevented from moving longitudinally. A part of the shaft extends beyond the bearing and lies within a second sealed chamber above. An outer shaft *C* coaxial with the inner member extends through bearings in the opposite wall of this second chamber. The ends of the two shafts within this second chamber are connected by bearing bushes to a driving pin *D*, which is inclined to their common axis, the centre of the pin lying on the common axis. A flexible impervious annular diaphragm *E* is bonded to the midpoint of this pin and its periphery is clamped between the two end halves of the casing of the second chamber to form a positive fluid tight seal. It will be appreci ted that the inner end of the second chamber on the lower side of the diaphragm is in communication with the main valve chamber and will be subject to the fluid pressure. The opposite end of the second chamber on the remote side of the diaphragm constitutes the backing pressure chamber and a rotary gland seal *F* is provided around the shaft *C* where it enters the chamber. When the shaft *C* is rotated the pin *D* imparts rotation to the inner member *G* which in turn moves the valve gate. During rotation of the driving pin the inner circular edge of the flexible diaphragm is caused to oscillate in the manner of a swash plate, whilst maintaining a positive fluid tight seal. When the valve is used for controlling fluids at relatively high pressure, this pressure will be exerted on the lower side of the diaphragm and there will be a consequent risk of rupture of the diaphragm. To reduce the loading on the diaphragm a pressure of water or oil is maintained in the backing chamber *H* on the outer side and any small escape of such fluid through the gland seal *F* around will not be of any serious consequence. Any escape of fluid from the backing chamber, however, will tend to cause a drop in pressure therein and distortion of the diaphragm, while the differential pressure on the diaphragm may undergo wide variations following variations in the pressure of the main fluid stream. In accordance with the invention, therefore, the ends of the second chamber on opposite sides of the diaphragm are connected to an auxiliary pressure chamber *J*. The auxiliary pressure chamber contains a corrugated flexible bellows one end of which is sealed to an end wall of the chamber while the other end is sealed to a movable piston. The diameter of the bellows is considerably smaller than that of the chamber and the space between the bellows and the wall is connected via passageway *K* to the backing pressure chamber while the cavity within the bellows is connected via passage *L* to the opposite end of the second chamber. Any escape of fluid from the backing chamber *H* will result in a reduction in pressure in the outer space of the auxiliary chamber and the piston will move to the left to reduce the volume of this space under the fluid pressure in its internal cavity. Backing fluid will thus be displaced into the backing chamber to restore the balance of pressure across the main diaphragm. This bellows device will thus provide automatic compensation for leakage of backing fluid up to the limit of the travel of the piston. Means are provided for admitting additional make-up fluid to the backing pressure chamber when the piston approaches the limit of its travel.—*December* 7, 1960.

RADAR

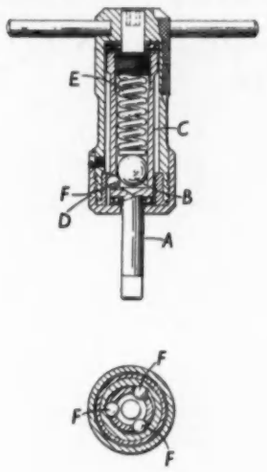
854,604. May 17, 1957.—DUPLEXER DEVICES, Compagnie Francaise Thomson-Houston, 173, Boulevard Haussmann, Paris (8e), France.

This invention relates to duplexer devices, and has application in pulse radar equipments arranged for common aerial working. In such equipments both the transmitter and receiver are connected to a single antenna. It is necessary to isolate the receiver from the transmitter during the transmission period and to decouple the transmitter from the receiver during the reception period. Devices for effecting this are known as duplexers. It is an object of the invention to provide a duplexer device having an extremely rapid de-ionisation time. The device comprises an envelope containing gas at a low pressure together with means for producing a magnetic field in a direction perpendicular to the required path of the discharge and of such magnitude relative to the operating frequency of the device that cyclotron resonance is induced and a discharge struck thereby. Thus although the pressure of the gas is too low for a discharge to build up under normal conditions, the cyclotron resonance effect will cause a sufficient number of collisions between the electrons and uncharged particles to enable the discharge to be established in a very short time. As regards the nature of the gas used, a gas with a smaller molecular weight will diffuse more rapidly since the mean thermal velocity is inversely proportional to the square root of the mass of the particles. However, certain heavy gases possess good properties. For instance the rare gases have the advantage of being chemically inactive. Mercury vapour is also useful since the pressure can be maintained constant during the life of the tube by the provision of a reservoir of mercury within the envelope.—*November* 23, 1960.

TOOLS

856,136. March 25, 1957.—TORQUE LIMITING WRENCHES, M.H.H. Engineering Company, Ltd., Bramley, near Guildford, Surrey. (*Inventor : Norman Harold Ellsey.*)

Referring to the drawing, this torque limiting wrench comprises generally an outer casing mounting an adaptor *A* having a squared end for standard sockets and screwdrivers. Drive from the casing to the adaptor is by a rotating ball clutch indicated generally at *B*, the load setting means comprising a spring and adjusting screw within the casing. Within the casing is a rotatable cylinder *C* terminating at one end in the spindle providing the adaptor and having at the open end a counterbore within which is secured a flanged collar *D* by which it is secured in position on the case by a screw cap. A ball thrust race is fitted between the upper ends of the housing and the casing and there is a second ball race at the lower end. Within the housing is a tension spring *E*, the coil at its lower end bearing through a spigot piece against a large ball which in turn bears against three steel balls *F* in radial slots in the wall of the housing at its lower end, where it overlaps the collar. Opposite the slots on the inside of the collar are three "cam" grooves in which the balls can move. It will be appreciated that so long as the balls remain partly in the grooves, rotation of the casing will transmit drive through the balls to the housing. At its upper end the spring is seated against an adjusting screw having a spigot which extends into an axial opening in the head of the casing. The



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torque applied through the balls to the driven member can be varied by adjusting the load of the spring through the adjusting screw. Under normal conditions of operation the balls will be maintained in the cam grooves due to the thrust from the spring through the large ball. As torque is applied the balls will be forced out of the their grooves and into the recesses in the housing ; when the limiting torque is reached, the balls will be forced sufficiently far back, by withdrawal of the large ball against the spring loading to allow the casing to rotate relative to the driven member.—*December* 14, 1960.

ELECTRICAL ENGINEERING

856,056. September 16, 1957.—CONTACTS FOR ELECTRIC SWITCHES, J. A. Crabtree and Co., Ltd., and Joseph Thom Carding and Gordon Albert Jelley, both of the company's address, Lincoln Works, Lincoln Road, Walsall, Staffordshire.

This invention is particularly concerned with contacts for electro-magnetically-operated motor starters, its object being to provide an improved arrangement for eliminating or minimising bounce of the moving contact when making engagement with its fixed contact, thereby reducing the possibility of the contacts welding and ensuring long life. The moving contact is carried on a piston in an actuating cylinder, on the inner surface of which is a viscous material affording a fluid-tight fit of the piston for creating a vacuous condition between the piston and the closed end of the cylinder when the piston is carried along the cylinder due to the impingement of the moving contact on a fixed contact. Thus the moving contact is retarded and its bounce is virtually eliminated because the formation of vacuous conditions absorb the energy of the shock without the piston setting up subsidiary shocks similar to those inherent with a mechanical spring. The moving contact may comprise a plate mounted on a sleeve-like piston disposed in the cylinder, a small quantity of grease being introduced between the piston and the cylinder. The contact plate may be carried on the free end of a piston-rod comprising a pair of flat plates, around which a spring is coiled, this spring becomes operative between a member bearing on the cylinder and the piston and acting also for compressing a washer against the piston head. The cylinder is connected with actuating means and its movement carries the moving contact plate into engagement with the fixed contacts. Upon such high-speed engagement the plate is arrested and the cylinder continues its movement for a short distance. During this period the space between the closed end of the cylinder and the piston is slightly enlarged, the grease constituting a fluid-tight seal around the piston. Hence a vacuous condition is set up. In effect the air behind the piston acts as an extensible high rate spring operating in a sealed space for a short period of the order of one millisecond.—*December* 14, 1960.

Catalogues and Brochures

CONSOLIDATED PNEUMATIC TOOL COMPANY, Ltd., 232, Dawes Road, London, S.W.6.—Brochure giving details of a range of oil flooded rotary portable "Power Vane" compressors.

AIR PROCESS UNITS, Ltd., 3, Tottenham Street, London, W.1.—Leaflet containing technical information on a series of self-contained air conditioners for fine-limit control of temperature and humidity.

COMMUNICATION SYSTEMS, Ltd., Norfolk House, Norfolk Street, London, W.C.2.—Illustrated pamphlet describing type 58 private automatic telephone exchange, designed for use in systems covered by M.O.P. certificate I.S. 1142 (Methane).

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Jan. 20.—STOKE AND CREWE BRANCH: Grand Hotel, Hanley, "Semi-conductors and Transistors," A. A. Shepherd, 7.30 p.m.

Thurs., Jan. 26.—SOUTH LONDON BRANCH: Greyhound Hotel, High Street, Croydon, "Airport Control," L. A. Mulligan, 8 p.m. ★ SOUTHAMPTON BRANCH: Polygon Hotel, Southampton, "Flight Refuelling," 7.30 p.m.

BRITISH INSTITUTE OF MANAGEMENT

Wed., Jan. 25.—Connaught Rooms, London, W.C.2, Foreman Training Conference, "The Selection and Status of the Foreman," D. W. Cole, 9.30 a.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Jan. 25.—ELECTRO-ACOUSTICS GROUP: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Noise Correlation Measurements," K. R. McLachlan, 6.30 p.m.

BRITISH NATIONAL SOCIETY OF SOIL MECHANICS AND FOUNDATION ENGINEERING

Wed., Jan. 25.—RANKINE LECTURE: Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Inaugural lecture, "Analysis and Control of Seepage for Dams," A. Casagrande, 5.30 p.m.

CEMENT AND CONCRETE ASSOCIATION

Mon., Jan. 23.—PRESTRESSED CONCRETE DEVELOPMENT GROUP: Friends House, Euston Road, London, N.W.1, "A Review of Advances in Prestressed Concrete in the U.S.A.," T. Y. Lin, 6 p.m.

Wed., Jan. 25.—Building Centre, 26, Store Street, London, W.C.1, Films, "Spelga Dam (Northern Ireland)," and "Building for a Nuclear Age," 12.45 p.m. ★ MILFORD HAVEN SECTION: The Ballroom, Lord Nelson Hotel, Milford Haven, Film Show, 7 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Tues., Jan. 24.—NORTH WESTERN REGION: Engineers' Club, Albert Square, Manchester, "Heating and Ventilation Problems," J. B. Atherton, 2.30 p.m.

Wed., Jan. 25.—MIDLAND REGION: Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2, Discussion on "Efficient Use of Gas in Industry," opened by A. C. Jennings, 10.30 a.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Jan. 23.—LEEDS CENTRE: British Lighting Council, 24, Aire Street, Leeds, 1, "Daylighting in Public Buildings," G. Ellis Miles, 6.15 p.m. ★ LEICESTER CENTRE: Sports Club, East Midlands Electricity Board, Leicester, Discussion on "Future Lighting for Night Travel on the Roads," 6.15 p.m.

Mon., Jan. 30.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Visual Perception," R. G. Hopkinson, 6 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., Jan. 25.—LONDON BRANCH: Constitutional Club, Northumberland Avenue, London, W.C.2, "Developments in the Production of Gunmetal Castings," F. Hudson, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., Jan. 24.—DEVON AND CORNWALL SECTION: Plymouth and Devonport Technical College, Plymouth, Annual General Meeting, and "Marine Steam Boilers," A. P. Monk, 7 p.m. ★ LONDON SECTION: Memorial Building, 76, Mark Lane, London, E.C.3, "Funnel Design and the Smoke Plume," A. D. Third and E. Ower, 5.30 p.m.

Thurs., Jan. 26.—WEST MIDLANDS SECTION: Engineering Centre, Birmingham, Annual General Meeting, and "A New Compact Design of Gas-Cooled Reactor Installation for Marine Use," C. Hartnell-Beavis, 6.30 p.m. ★ KINGSTON UPON HULL AND HUMBER AREA SECTION: Royal Station Hotel, Kingston upon Hull, Annual General Meeting, 7.30 p.m. ★ NORTH EAST COAST SECTION: Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, "The Future Doxford Marine Oil Engine," P. Jackson, 6.15 p.m.

Fri., Jan. 27.—MERSEYSIDE AND NORTH WESTERN SECTION: Central College of Further Education, Barrow-in-Furness, Joint meeting with the Barrow Association of Engineers, "Oil Fuel Burning," A. H. Skinner, 7.30 p.m.

INSTITUTE OF METALS

Wed., Jan. 25.—MANCHESTER METALLURGICAL SOCIETY: Manchester Literary and Philosophical Society, George Street, Manchester "The X-ray Microanalyser as a Research Tool for the Metallurgist," D. A. Melford, 6.30 p.m.

Thurs., Jan. 26.—SOUTHAMPTON METALLURGICAL SOCIETY: The University, Southampton, "Hot Dip Galvanising," M. H. Davis, 7.15 p.m. ★ WEST OF ENGLAND METALLURGICAL SOCIETY: College of Technology, Ashley Down, Bristol, 7, "Recent Developments in Metallography," R. W. K. Honeycombe, 7.30 p.m.

INSTITUTE OF NAVIGATION

To-day, Jan. 20.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Presentation of Height Information in Aircraft," A. Stratton and K. R. Honick, 5.15 p.m.

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY

To-day, Jan. 20.—Royal Horticultural Society's Old and New Halls, Westminster, London, S.W.1, Annual Exhibition.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, Jan. 20.—SOUTH WALES CENTRE: South Wales Institute of Engineers, Park Place, Cardiff, "The Design of Commercial Vehicles for Transcontinental Haulage," Mario Persia, 7.15 p.m.

Thurs., Jan. 26.—NORTHERN CENTRE: Commercial Hotel, Accrington, "Recent Developments in Head Lighting," J. H. Nelson, 7.30 p.m.

Mon., Jan. 30.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Servicing in the Field," 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Jan. 24.—LONDON BRANCH: Geological Society, Burlington House, London, W.1, "A Survey of Chemical Engineering Education and Practice," R. Edgeworth Johnstone, 5.30 p.m. ★ NORTH WESTERN BRANCH: Technical College, Birkenhead, "Experimentation and Reactor Design in Process Research and Development," W. Waddington and W. D. Betts, 7.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Jan. 24.—Great George Street, Westminster, London, S.W.1, "The Choice of Protective Schemes for Structural Steelwork," F. Fancutt and J. C. Hudson, 5.30 p.m.

Thurs., Jan. 26.—TRAFFIC ENGINEERING STUDY GROUP: Great George Street, Westminster, London, S.W.1, Discussion on "The Work of the Graduate School of Highway Engineering, University of Birmingham," introduced by F. D. Hobbs, 5.30 p.m.

INSTITUTION OF ELECTICAL ENGINEERS

To-day, Jan. 20.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Management Studies for Junior Engineers," opened by G. S. C. Lucas, 6 p.m.

Mon., Jan. 23.—LONDON GRADUATE AND STUDENT SECTION: Savoy Place, London, W.C.2, "Economic Heating, by Electrode Boilers, in Industry," G. A. Williams, 6.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Royal Institution, Colquitt Street, Liverpool, Joint meeting with the North-Western Branch of the Institution of Mechanical Engineers and the Liverpool Engineering Society, "Cybernetics," J. C. West, 6.30 p.m. ★ SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP: James Watt Memorial Institute, Birmingham, "Applications of Microwaves," A. L. Cullen, 6 p.m. ★ WESTERN UTILISATION GROUP: South Wales Institute of Engineers, Park Place, Cardiff, "The Utilisation of Electricity in Steelworks," T. B. Rolls, 6 p.m.

Tues., Jan. 24.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, Discussion on "Machine-Tool Control," opened by E. H. Frost-Smith, 5.30 p.m. ★ NORTH WESTERN CENTRE: Free Trade Hall, Manchester, Faraday Lecture, "Transistors and All That," L. J. Davies, 7.30 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "The Changing Face of Electronics," W. E. J. Farvis, 7 p.m.

Wed., Jan. 25.—ELECTRONICS AND COMMUNICATIONS SECTION: Savoy Place, London, W.C.2, "Generation and Amplification in the Millimetre Wave Field," W. E. Willshaw, 5.30 p.m.

Thurs., Jan. 26.—NORTH MIDLAND CENTRE: Town Hall, Leeds, Faraday Lecture, "Transistors and All That," L. J. Davies, 7 p.m.

Mon., Jan. 30.—ARBORFIELD DISTRICT MEETING: Unit Cinema, 3 (Tels.) Training Bn., R.E.M.E., Arborfield, Berks., "Automatic Trunk Dialling," H. E. Francis, 7 p.m. ★ SOUTH EAST SCOTLAND SUB-CENTRE, GRADUATE AND STUDENT SECTION: Canteen, South of Scotland Electricity Board, Dewar Place, Edinburgh, "The Application of Electronics to Chemical and Gas Analysis," G. J. Geis, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Jan. 31.—39, Elmbank Crescent, Glasgow, Hugh Macmillan Memorial Lecture, "The Interdependence of Engineering and Chemistry," Sir Alexander Fleck, 6.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Jan. 20.—N.E. BRANCH GRADUATES' SECTION: Rutherford College, Newcastle, "Problems in the Design and Operation of Ejectors," M. O. Engel, 6.30 p.m.

Sat., Jan. 21.—E. MIDLANDS GRADUATES' SECTION: Visit to Derby Evening Telegraph, Northcliffe House, Derby, 10.45 a.m.

Mon., Jan. 23.—LUBRICATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Co-ordination of Experimental Work" opened by H. J. Watson, 6 p.m. ★ NORTH WESTERN BRANCH: Royal Institution, Liverpool, "Cybernetics," Professor West, 6.30 p.m.

Tues., Jan. 24.—NORTH WESTERN BRANCH: Liverpool Engineering Society, Liverpool, "The Durgapur Steelworks Power Station," G. Cooke, 6 p.m. ★ BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, "Applications of Statistical Methods to Technical Problems," D. J. Desmond, 6.30 p.m. ★ SOUTH WALES BRANCH: South Wales Institute of Engineers, Cardiff, "Sealing Characteristics of Stuffing-box Seals for Rotating Shafts," D. F. Denny, and D. E. Turnbull, 6 p.m. ★ WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Initiation and Some Controlling Parameters of Combustion in the Piston Engine," J. S. Clarke, 7.30 p.m. ★ COVENTRY GRADUATES' SECTION: Visit to Police Headquarters, Coventry, 7.30 p.m. ★ EASTERN GRADUATES' BRANCH: Visit to Ipswich Waterworks, 7 p.m. and Visit to the Empire Rubber Company, Dunstable, Beds., 7.30 p.m. ★ LONDON GRADUATES' BRANCH: 1, Birdcage Walk, London, S.W.1, "Food Machinery," E. W. Scarpa, 6.30 p.m. ★ SCOTTISH GRADUATES' BRANCH: South Engineering Building, The University, Glasgow, "Developments in Piston Aero-engines," E. L. S. McLay, 7.30 p.m. ★ SOUTHERN GRADUATES' BRANCH: Sun Hotel, Chatham, Film Show, "Test Flight, 263, Mediterranean Cape Rally, 1953," 7 p.m.

Wed., Jan. 25.—THOMAS LOWE GRAY LECTURE: 1, Birdcage Walk, Westminster, London, S.W.1, "The Early Development of the Dracone Flexible Barge," W. R. Hawthorne, 6 p.m. ★ SOUTHERN BRANCH: Technical College, Reading, Discussion on "Organising and Designing for Safety in the Engineering Industry," opened by H. van de Vord, 7.30 p.m. ★ EAST MIDLANDS GRADUATES' SECTION: Technical College, Cathedral Street, Lincoln, Film Show, 7.15 p.m. ★ NORTH EASTERN GRADUATES' SECTION: Cleveland Scientific and Technical Institution, Middlesbrough, "A Review of Safety Features in Drum-winding Engines," S. Parker, 6.30 p.m. ★ SOUTHERN GRADUATES' SECTION: Sports Pavilion, A.W.R.E., Aldermaston, "Non-Destructive Testing," R. W. Parish, 3 p.m.

Thurs., Jan. 26.—APPLIED MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Applications of Electronic Computers in the Study of Applied Mechanics and Electronic Computing in Engineering Design," 6 p.m. ★ EAST MIDLANDS BRANCH: Lecture Theatre, College of Further Education, Loughborough, "The Potentialities of Accurate Measurement and Control in Engineering," J. Loxham, 7.30 p.m. ★ NORTH EASTERN BRANCH: Stephenson Building, Claremont Road, Newcastle upon Tyne, Meeting organised by the North East Coast Section of the Institute of Marine Engineers, "The Future Doxford Marine Oil Engine," P. Jackson, 6.15 p.m. ★ NORTH WESTERN BRANCH: Literary and Philosophical Society's Rooms, Manchester, "Pressure Vessels for Gas-Cooled Graphite Moderated Reactors," M. J. Noone and R. F. Bishop, 6.45 p.m.

INSTITUTION OF MINING ENGINEERS

Fri., Jan. 27.—Royal Institution of Naval Architects, 10, Upper Belgrave Street, London, S.W.1, Sixty-Seventh Annual General Meeting, 11.15 a.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Jan. 24.—SOUTH WALES BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, "Industrial Flooring," E. Davison, 7.30 p.m.

Thurs., Jan. 26.—MERSEYSIDE AND NORTH WALES BRANCH: Exchange Hotel, Liverpool, "Steam," J. S. Brundrit, 7.15 p.m. ★ SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "Roller Bearings for Some Heavy Engineering Applications," A. Pollock, 7.30 p.m.

Fri., Jan. 27.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Power Tractor Correction of Electrical Plant," G. Hoyland, 7.30 p.m.

Mon., Jan. 30.—WEST AND EAST YORKSHIRE BRANCH: Houldsworth School of Applied Science, The University, Leeds, "The Uses of Molybdenum Disulphide," G. J. Vineall, 7.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Sat., Jan. 21.—LEEDS GRADUATE SECTION: Visit to Wool Industries Research Association, Torridon, Headingley, Leeds, 10 a.m.

Tues., Jan. 24.—NORTH MIDLANDS REGION, LOUGHBOROUGH COLLEGES STUDENT SECTION: Room A-1, Schofield Building, Loughborough College of Technology, Loughborough, "The Contract of Toolmaking Industry," F. O. Harrison, 7.30 p.m.

Wed., Jan. 25.—MIDLANDS REGION: New Technical College, Shrewsbury, "Latest Developments in Palletisation," J. F. Harvey, 7.30 p.m. ★ MIDLANDS REGION: Star Hotel, Worcester, "Gear Cutting," J. R. Hopkins, 7.30 p.m. ★ SOUTH EASTERN REGION: Old Ship Hotel, Castle Square, Brighton, "An Introduction to the Flow Turning Process," E. J. Bennett, 7 p.m. ★ 1961 LORD SEMPILL PAPER: Lecture Theatre, Royal Aeronautical Society, 4, Hamilton Place, London, W.1, "The World's Future Transport Requirements," Sir Percy Hunting, 6.30 p.m.

Fri., Jan. 27.—NORTH MIDLANDS REGION: Louis Room, St. James Restaurant, Derby, "The Manufacture of a Motor Car," G. Irvin, 7 p.m.

Mon., Jan. 30.—NORTH WESTERN REGION: Reynolds Hall, Manchester College of Science and Technology, Manchester, "The Design of Bluebird," D. Stevens, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Mon., Jan. 23.—MERSEYSIDE PANEL: Liverpool University, New Civil Engineering Building, Brownlow Hill, Liverpool, "Prestressed Concrete and C.P. 115," A. J. Harris, 6.30 p.m.

Tues., Jan. 24.—SCOTTISH BRANCH: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Provisions of the Revised British Standard for the Use of Structural Steel in Building—B.S. 449/1959," W. C. Andrews, 7 p.m.

Wed., Jan. 25.—EDINBURGH SECTION: Heriot-Watt College, Edinburgh, "The Provisions of the Revised British Standard for the Use of Structural Steel in Building—B.S. 449/1959," W. C. Andrews, 6.30 p.m.

Thurs., Jan. 26.—11, Upper Belgrave Street, London, S.W.1, "The Design and Construction of Extension to British European Airways Engineering Base at London Airport," P. B. Edwards and R. B. Rigg, 6 p.m.

Fri., Jan. 27.—MIDLAND COUNTIES BRANCH: Byng Kerrick Suite, College of Advanced Technology, Gosta Green, Birmingham, 6, "The Structural Engineer in the Field of Atomic Energy," T. C. Waters, 6.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Jan. 20.—Pepys House, 14, Rochester Row, London, S.W.1, "Radio Investigations of the Solar Atmosphere," J. Heywood, 7 p.m.

Fri., Jan. 27.—Pepys House, 14, Rochester Row, London, S.W.1, "Pingon Tower Cranes and their Applications," A. H. Davies, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., Jan. 27.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "Marine Steam Turbine Design and Operation," A. F. Veitch, 6.15 p.m.

ROYAL AERONAUTICAL SOCIETY

To-day, Jan. 20.—MAN POWERED AIRCRAFT GROUP: Lecture Theatre, 4, Hamilton Place, London, W.1, "Gliding and Man Powered Flight," Lorne Welch, 7 p.m.

Mon., Jan. 23.—AGRICULTURAL AVIATION GROUP: Lecture Theatre, 4, Hamilton Place, London, W.1, "Locust Control from the Air," R. C. Rainey, 7 p.m.

Tues., Jan. 24.—Lecture Theatre, 4, Hamilton Place, London, W.1, "Some Problems of Impact and Evasion in Flight," A. A. Fyall, D. C. Jenkins and R. N. C. Strain, 7 p.m.

ROYAL INSTITUTION OF CHARTERED SURVEYORS

Mon., Jan. 23.—TOWN PLANNING GENERAL MEETING: 12, Great George Street, Parliament Square, London, S.W.1, "Some Reflections on Property Development," E. C. Uren, 5.45 p.m.

ROYAL SOCIETY OF ARTS

Mon., Jan. 23.—CANTOR LECTURE: John Adam Street, Adelphi, London, W.C.2, "The Chemical and Plastics Industries," J. Taylor, 6 p.m.

Wed., Jan. 25.—ALFRED BLOSSOM LECTURE: John Adam Street, Adelphi, London, W.C.2, "Architecture in Transport," F. F. C. Curtis, 6 p.m.

ROYAL STATISTICAL SOCIETY

Thurs., Jan. 26.—SHEFFIELD GROUP: Sheffield University, Room Maths 4, Firth Building, Western Bank, Sheffield, "How can Statistics Help the Manager?" P. J. Stanley, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Thurs., Jan. 26.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, Conversazione, 6.30 p.m.

SOCIETY OF INSTRUMENT TECHNOLOGY

Thurs., Jan. 26.—CHESTER SECTION: Lecture Theatre, Administration Building, The Associated Ethyl Company, Ltd., Oil Sites Road, Ellesmere Port, Wirral, "Satellite Instrumentation," R. C. Jennison, 7 p.m.

TELEVISION SOCIETY

Thurs., Jan. 26.—FLEMING MEMORIAL LECTURE: Royal Institution, 21, Albemarle Street, London, W.1, "Behind the Eye," D. M. Mackay, 7 p.m.

UNIVERSITY OF LONDON

Mon., Tues., and Thurs., Jan. 23, 24 and 26.—Queen Mary College, Mile End Road, London, E.1, Course of three lectures on "Electrical Energy Conversion," David C. White, 5.30 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

To-day, Jan. 20.—Elmbank Crescent, Glasgow, "The Relative Merits of Different Steelmaking Processes," T. F. Pearson, 6.45 p.m.

Advanced Engineering Courses

Liquid Fuels, Their Properties and Utilisation. BOROUGH POLYTECHNIC, Borough Road, London, S.E.1. A course of six lectures, Tuesday evenings, commencing January 31 at 7 p.m. The course will provide a survey of present-day knowledge and will cover recent developments in both European and American practice. Fee 10s.

Developments Affecting the Control of Quality in Machine Tool Operations. BOROUGH POLYTECHNIC, Borough Road, London, S.E.1. A course of six lectures to be held on Wednesday evenings, commencing January 25 at 7 p.m. A survey of modern practice in the control of quality of the machine product with regard to dimensional accuracy, geometrical form and surface finish. The course is intended for production executives, mechanical engineers, electronic engineers and inspectors concerned with quality control. Fee 10s.

Experimental Stress Analysis. BOROUGH POLYTECHNIC, Borough Road, London, S.E.1. A course of seven lectures to be given on Thursday evenings, commencing January 26. A survey of the principles and techniques employed in the experimental determination of stresses in engineering structures and components. The course covers mechanical gauges, photo-elastic methods for two dimensional and three dimensional analysis, surface film techniques, electrical strain gauges, replica method and pneumatic extensometry. The course is intended for qualified engineers and for students in their final years. Fee £1.